Essays in Investment, Regulation and Labor Market Frictions

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ESSAYS ON INVESTMENT, REGULATION AND LABOR MARKET FRICTIONS

- THESIS ABSTRACT -

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This thesis focuses on investment, regulation and labor market frictions.

The first paper is motivated by lumpiness of investment activity at the plant level. Investment episodes at firm level happen in lumps, period of great activity and periods of inaction. Previous research has suggested that, in a general equilibrium framework, accounting for such microeconomic behavior is irrelevant for explaining aggregate investment (Thomas (2002)). This paper re-evaluates previous findings in a two-sector economy, where non-convex costs of capital adjustment apply to each sector. Calibrating the model to be consistent with microeconomic evidence, I find that lumpy investment is relevant for the business cycle. Through limited intersectoral mobility of capital, non-convex capital adjustment costs impact the relative price of investment generating a synchronization of investment decisions at sectoral level. As a result,

aggregate investment is amplified relative to neoclassical benchmarks in response to an aggregate productivity shock. In a one-sector model this mechanism is absent, since intersectoral capital mobility is perfect and the relative price of investment is independent from non-convex capital adjustment costs. In an empirical investigation of the model using 2-digit SIC industry data, I find evidence that sectoral measures of capital distribution forecast aggregate investment.

The second paper investigates the effect of product market liberalization on employment and considers possible interactions between policies and institutions in product and labor markets. Using panel data for OECD countries over the period 1980-2002, we present evidence that product market deregulation is more effective at the margin when labor market regulation is high. The data also suggest that product market deregulation promotes labor market deregulation. These results are consistent with the basic predictions of a standard bargaining model, such as Blanchard and Giavazzi (2003), extended to allow for a richer specification of the fall back position of the union.

In the third paper, we start from evidence that most countries in the Euro Area are characterized by high product (PMR) and labor market

(LMR) regulation. We then study long and short to medium run macroeconomic effects of reforming PMR and LMR by developing a dynamic stochastic general equilibrium model featuring endogenous producers entry and labor market frictions. We show that lowering PMR would increase steady state employment, wages and GDP but aggregate consumption would drop in the aftermath of the reform. Deregulating labor markets presents a less significant intertemporal trade off. Lower unemployment benefits would increase employment and GDP but reduce wages both in the short and long run. Smaller firing costs would trigger a positive effect on producers entry on impact, but employment and GDP would be negatively affected as time passes by. Regulation has also consequences for the business cycles properties of the economy. Lower barriers to entry and smaller unemployment benefits tend to smooth out aggregate fluctuations, while firing costs have a reverse effect. With a counterfactual exercise, we show that if the Euro Area would deregulate both product and labor markets at the US level it would adjust differently to aggregate shocks. A more flexible Euro Area would be more responsive to exogenous disturbances and the reversion to the steady state would be quicker. Our findings point out that concerns about the negative effect of strict regulation for the speed of recovery from downturns could be well placed, consistently with the idea that the European economy might be dynamically sclerotic.

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Chapter 1

Lumpy Investment Is Relevant for the Business Cycle

1.1 Introduction

Investment at the plant level is a large and infrequent, or *lumpy,* episode (Doms and Dunne (1998)). Aggregate investment is instead gradual and smooth. Thomas (2002) assumes non-convex costs of capital adjustment and derives generalized *(S,s)* adjustment rules that generate lumpy investment at plant level within an otherwise standard one-sector business cycle model. She finds that accounting for microeconomic lumpy investment is irrelevant for explaining aggregate investment. General equilibrium effects, i.e. movements in the prices of production factors, smooth investment heterogeneity at plant level and yield quantity dynamics that are virtually indistinguishable from the standard model.

This paper re-evaluates the relevance of lumpy investment in explaining aggregate investment in a two-sector economy. I adopt a two-sector specification of the technology:

one sector produces consumption good and the other the investment good. Lumpiness is modeled as in Thomas (2002). Plants in each sector face non-convex costs of capital adjustment. As a result, increasing sectoral capital or reallocating it across sectors is costly. The assumptions are consistent with empirical evidence in Ramey and Shapiro (2001) who suggest significant sectoral specificity of physical capital and substantial costs of redeploying the capital. The model is calibrated to reproduce microeconomic evidence in Gourio and Kashyap (2007): changes in the number of establishments undergoing investment spikes, defined as investment rate above 20%, account for a large fraction of variation in aggregate investment. Contrary to findings in previous literature, the dynamics generated by a two-sector model with lumpy investment in response to an aggregate productivity shock differ from two neoclassical benchmarks: one without adjustment costs (frictionless), and the other with convex costs of adjusting capital at sectoral level. I find that the model with lumpy investment simultaneously reconciles microeconomic lumpiness with a gradual, hump-shaped response of aggregate investment consistent with VAR evidence in Christiano et al. (2004). The propagation mechanism is qualitatively the same in all the three setup considered. When the shock hits the economy, the shadow value of capital increases and the planner wants to reallocate investment to the production of the investment good. As the shadow value of capital decreases to return to its steady state value, investment is allocated to the consumption sector. Both consumption and investment increase.

In the frictionless model, the reallocation of resources is immediate. Investment in the investment sector spikes, and a large fraction of depreciated capital in the consumption sector is not replaced. Over time, the process is reversed: investment in the consumption sector increases and capital depreciated in the investment sector is not replaced. Aggregate investment spikes in the second period and then monotonically declines to steady state level.

In the lumpy model, due to non-convex costs of adjusting capital, plants follow generalized *(S,s)* adjustment rules that allow for probabilistic bands of inaction, where the likelihood of a discrete adjustment rises with deviation of a plant's state from its desired value. The model delivers two sectoral distributions of establishments over capital levels. When the aggregate productivity shock hits the economy, the presence of non-convex costs slows down the build-up of capital in the investment sector and as a result the relative price of investment is higher relative to the frictionless case. Movement in the relative price of investment synchronizes investment decision at sectoral level. Plants in the investment sector increase their stock of capital. Plants in the consumption sector forgo investment as depreciated capital is not replaced. As a result, in the consumption sector, a larger fraction of plants relative to steady state has a large capital imbalance that combined with the increasing likelihood of investing generates an amplification of aggregate investment relative to the frictionless case.

In the model with convex costs of capital adjustment, the response of aggregate investment is muted relative to the lumpy model. Convex costs of adjusting capital symmetrically apply to variations in the stock of capital, both upward and downward: reducing the stock of capital in the consumption sector is costly as it is the build-up of capital in the investment sector. As a result, convex adjustment costs dampen the response of investment relative to the frictionless case and the lumpy model.

I find that, in a two-sector economy accounting for lumpy investment is relevant in explaining aggregate investment. Non-convex costs of capital adjustment limit intersectoral mobility of capital and thus affect the relative price of investment and in turn aggregate investment dynamics. In a one-sector model as in Thomas (2002), this mechanism is absent. Capital is perfectly mobile across sectors and non-convex costs of adjusting capital do not have any effect on the relative price of investment.

In the second part of the paper, I analyze the impact of sectoral variations in the number of establishments undergoing investment spikes on aggregate investment as Gourio and Kashyap (2007). While they focus on measure of spikes for the entire manufacturing, I look at sectoral measures to be consistent with the lumpy model analyzed in the first part of the paper. I construct two separate measures: one for the consumption and one for the investment sector. I use annual 2-digit SIC industry data from Annual Survey of Manufactures from 1974 to 1998. I divide industries in consumption and investment sector based on the destination of their output through an Output-Use matrix from Bureau of Economic Analysis. Sectoral measures of spikes forecast aggregate investment rate, even controlling for past investment rate and past sales. The quantitative impact of measures of spikes on aggregate investment is sector specific. An increase of one standard deviation in the number of establishments undergoing spikes in the consumption sector results in a decrease of aggregate investment rate equal to 0.6%. If the increase comes from the investment sector, aggregate investment decreases by 1.1%. The impact on aggregate investment rate of variation in spikes is therefore substantial. The empirical analysis supports the modeling strategy adopted in the paper.

The remainder of the paper is organized as follows. Section 2 briefly reviews previous research related to the state dependent lumpy investment model developed here. Section 3 and 4 present the model and the choice of the parameters. Section 5 presents the steady state results and the economy's dynamics relative to two neoclassical benchmarks: one frictionless and the other with convex costs of capital adjustment. Section 6 describes an empirical investigation of the model. Section 7 concludes the paper.

1.2 Related Literature

The literature displays examples of models where due to non-convexities investment decision at plant level are characterized by *(S,s)* policies: periods of investment activity are followed by periods of inactivity[1]. Caballero and Engel (1999) develop a generalized *(S,s)* adjustment model in partial equilibrium that allows for probabilistic bands of inaction, so that the likelihood of a discrete adjustment rises in the deviation of a plant's state from its desired value. They find that their model perform better than the standard linear model of investment in explaining two-digit US manufacturing investment.

Thomas (2002) is the first study that incorporates in a general equilibrium framework a generalized (S,s) model of establishment-level investment within a standard neoclassical growth model. Contrary to previous literature, aggregate effects of lumpy investment are negligible due to households' preferences for smooth consumption profiles. The results are robust to different modifications. Khan and Thomas (2003) analyze the impact of investment specific shock, and Khan and Thomas (2008) include also heterogeneity in total factor productivity.

Gourio and Kashyap (2007), using plant level data from Chile and U.S., show that investment spikes, surge in investment defined by an investment rate above 20%, are highly procyclical. The extensive margin accounts for roughly 90% of the variance in aggregate

[1]Examples of (S, s) investment models include Caballero and Engel [1991], Bertola and Caballero [1994], Abel and Eberly [1996], and Caballero and Leahy [1996].

investment. They recalibrate the model in Thomas (2002) to be consistent with their findings, even in this case the irrelevance result persists.

Bachmann et al. (2006) have challenged the irrelevance result building a model with idiosyncratic productivity shock, a continuum of sectors and maintenance investment. Lumpy investment is relevant when households are almost risk-neutral. Their multisector framework does not consider linkages across sectors and differences between the lumpy and the frictionless case arise at long frequency.

House (2008) shows that neoclassical investment models and fixed-cost models share a near-infinite intertemporal elasticity of investment that is responsible for the result. His analysis shows that irrelevance result obtained in fixed-cost models reflect fundamental properties of long-lived investments.

All the studies mentioned above, analyze one sector model. Theoretical models, with the exception of Bachmann et al. (2006), point toward the irrelevance of lumpy investment, while empirical studies find a role for lumpy investment. Cooper and Haltiwanger (2006) study the nature of capital adjustment cost at plant level. Using an indirect inference method they estimate the structural parameters of a rich specification of capital adjustment cost. Their findings indicate that a model, which mixes both convex and non-convex adjustment costs, fits the data better. Gourio and Kashyap (2007) emphasize the empirical relevance of non-convexities at plant level and the relevance in explaining aggregate investment. I explore a more general setup than the one analyzed in the literature. I include a mechanism that generates lumpy investment in a two sector model to study whether the irrelevance result survives in a model in which also the relative price of investment, unlike the one sector model, responds to state of the economy.

1.3 A Two-Sector Model with Lumpiness

This section describes the model. I introduce lumpiness in a two-sector neoclassical growth model. Non-convex costs of capital adjustment apply to plants in each sector. Investment decisions at plant level are subject to a random cost drawn from a known distribution. The fixed cost induces a distribution of plants over capital levels, one for each sector. As in Thomas (2002) I model state-dependent investment at the plant level using a generalized *(S,s)* framework. The approach is related to Caballero and Engel (1999) generalize *(S,s)* model in its use of stochastic adjustment costs to simultaneously yield lumpy plant-level investment and smooth aggregates. This approach allows for probabilistic adjustment thresholds that can capture the rising hazards observed in microeconomic data. The description of the model follows Thomas (2002).

1.3.1 Production and Investment Decisions at Plant Level

This subsection describes production and investment decisions in the economy.

I adopt a two-sector specification of technology. One sector produces consumption goods and the other produces investment goods. In each sector there is a continuum of production units that are heterogeneous in their stocks of capital. As in Thomas (2002), I abstract from entry or exit of establishments. Production technology at plant-level displays diminishing return to scale. Plants produce using capital and labor as variable inputs. Labor can be freely adjusted in each period, while capital adjustment is subject to a fixed labor cost. These adjustment costs, denoted by ξ, are independently and identically distributed across establishments and across time with a known cumulative distribution of $G_s(\xi)$ and finite upper support B_s. The subscript s represents the sector to which the variable refers to: C for consumption sector, and K for investment sector. The fixed cost is denominated in unit of labor to ensure that plants cannot outgrow adjustment costs along the balance growth path.

A production unit that has adjusted its level of capital j periods ago will have its capital denoted by a subscript j. All plants in both sectors share the same production technology with diminishing return to scale with respect to the two inputs of production, capital $k_{j,t,s}$ and labor $n_{j,t,s}$. The production function is a Cobb-Douglas:

$$y_{j,t,s} = A_t k_{j,t,s}^{\gamma} n_{j,t,s}^{\nu}, \tag{1.1}$$

All establishments share the same productivity A_t that is determined by the realization of a stochastic component, z_t, and a trend component, X_t. The component X_t evolves deterministically with growth rate Θ_A, and z_t follows a mean zero AR(1) process in logs:

$$A_t = X_t z_t, \tag{1.2}$$

$$z_t = z_{t-1}^{\rho} e^{\epsilon}, \text{ and } \epsilon \tilde{\ } N(0,\sigma^2). \tag{1.3}$$

In each period, plants in each sector, after observing the realization of aggregate productivity and its individual adjustment cost, decide whether to invest. If a plant decides to adjust its stock of capital for date $t+1$ production, it pays its current cost draw ξw_t, in unit of output (w_t represents the real wage at date t) and invest to reach a target level of capital

$k_{0,t+1,s}$.

$$k_{0,t+1,s} = (1-\delta)k_{j,t,s} + i_{j,t,s} \; ; \; s = C, K; \; j = 1...J_s. \tag{1.4}$$

If an establishment stays inactive, its stock of capital next period is the depreciated current level of capital.

$$k_{j+1,t+1,s} = (1-\delta)k_{j,t,s} \; ; \; s = C, K; \; j = 1...J_s. \tag{1.5}$$

Each plant's current flow of profit is determined by its total revenues less wage payments, investment and adjustment costs. Given diminishing returns plants makes profits that are rebated to households in lump-sum fashion. Total revenues differ across sectors, since the price of consumption is normalized to 1, and plants in the investment sector sell their output at the relative price of investment.

1.3.2 Aggregation at sectoral level

This section describes how individual plants are aggregated within each sector.

In each sector, all plants share the same technology and face the same distribution of adjustment costs. This implies that they share the same expected stream of future marginal revenues for any given choice of future capital. Thus investors choose a common target capital $k_{0,t+1,s}$. All plants adjusting at a given time are identical immediately after investing. The cross-sectional distribution of establishments over capital levels is therefore summarized by the distribution of plants across $time - since - adjustment$, or loosely vintages, where each member of a group shares the same time since last capital adjustment and it is associated with same capital stock. There are two distributions of plants over levels of capital, one for the consumption sector and one for the investment sector. Each group contains a marginal plant whose cost draw it is just worthwhile to invest. All plants of the same group drawing costs at or below this group-specific threshold also invest, implying the investing fraction for each group, $\alpha_{j,t,s}$, is retrievable from the adjustment cumulative density function (CDF).

At each date, the sectoral distribution of the economy's establishments across sectors is summarized by two vectors: $\mathbf{k}_{t,s}$ and $\boldsymbol{\vartheta}_{t,s}$.

The vector $\mathbf{k}_{t,s} = \{k_{j,t,s}\}$ represents the vector of capital levels across time-since-adjustment groups. The fraction of plants associated with each level of capital is given by the predetermined vector $\boldsymbol{\vartheta}_{t,s} = \{\vartheta_{j,t,s}\}$. Each $\vartheta_{j,t,s}$ describes the number of firms owing vintage j capital stock.

The evolution of the sectoral cross-sectional distribution is determined as follows. The support at time t+1 is determined through (1.5) and adjusting plants' common choice of $k_{0,t+1,s}$. Let denote the fraction of adjustment rates by $\boldsymbol{\alpha}_{t,s} = \{\alpha_{j,t,s}\}$.

The evolution of the distribution of plants $\boldsymbol{\vartheta}_{t+1,s}$ is determined by the following equations:

$$\vartheta_{0,t+1,s} = \sum_{j=0}^{Js} \alpha_{j,t,s}\vartheta_{j,t,s} \ ; \ s = C, K \ , \tag{1.6}$$

$$\vartheta_{j,t+1,s} = (1 - \alpha_{j,t,s})\vartheta_{j,t,s} \ ; \ i = C, K \ ; \ j = 1, 2...J. \tag{1.7}$$

The group of plants that have adjusted their stock of capital in the current period is the weighted sum of adjusters in each group. If plant decides not to adjust at date t, become vintage $t+1$ in the subsequent period. The total stock of capital of the economy is the sum of the stock of capital in each sector.

1.3.3 Households

A representative household owns the portfolio of plants in both sectors and supplies labor. The household values consumption and leisure according to a momentary utility function $u(C_t, 1 - N_t)$, where N_t is the fraction of time devoted to market activity, and discounts future utility by the factor β. Consumption is financed by labor income, and profits received from the plants.

1.3.4 Aggregate Constraints

The economy is subject to a set of aggregate constraints:

$$C_t \;\leq\; \sum_{j=0}^{J_C} \vartheta_{j,t,C}\; y_{j,t,C}\;, \tag{1.8}$$

$$I_{t,C} \;+\; I_{t,K} \;\leq\; \sum_{j=0}^{J_K} \vartheta_{j,t,K}\; y_{j,t,K}\;, \tag{1.9}$$

$$\sum_{j=0}^{J_C} \vartheta_{j,t,C}\; n_{j,t,C} \;+ \sum_{j=0}^{J_K} \vartheta_{j,t,C}\; \Xi(\alpha_{j,t,C}) + \; \sum_{j=0}^{Jc} \vartheta_{j,t,K}\; n_{j,t,K} + \sum_{j=0}^{J_K} \vartheta_{j,t,K} \Xi(\alpha_{j,t,K}) \leq N_t. \tag{1.10}$$

Household consumption cannot exceed the total production of consumption good. Aggregate investment cannot exceed the production of the investment sector. Total hours worked by the household must satisfy the weighted sum of employment in production and adjustment activities in each sector. Below is the average adjustment cost for each group in each sector.

$$\Xi(\alpha_{j,t+1,s}) = \int_0^{G_s^{-1}(\alpha_{j,t,s})} x dG_s(x). \tag{1.11}$$

1.3.5 Planner's Problem

Competitive equilibrium allocations are determined through the solution of a planning problem. Specifically, the planner maximizes the following problem:

$$\max_{C_t, \mathbf{i}_{t,s}, \mathbf{n}_{t,s}, \boldsymbol{\alpha}_{t,s}, \boldsymbol{\vartheta}_{t+1,s}, k_{0,t+1,s}, N_t} \sum_{r=0}^{\infty} \beta E_{t+r} u(C_{t+r}, 1 - N_{t+r})], \tag{1.12}$$

subject to (1.1), (1.4), (1.5), (1.6), (1.7), (1.8), (1.9), (1.10)

The solution of a planning problem satisfies a series of efficiency conditions:

$$\lambda_t = D_1 u(C_t, 1 - N_t), \tag{1.13}$$

$$w_t = \frac{D_2 u(C_t, 1 - N_t)}{D_1 u(C_t, 1 - N_t)}, \tag{1.14}$$

The first order condition for consumption (C_t) in equation (1.13) equalizes the multiplier on the constraint of equation (1.8) with the marginal utility of consumption, where D represent the first derivative of the utility function and the subscript denotes the argument with respect to what the derivative is taken. Total labor hours equate the marginal rate of substitution between leisure and consumption to w_t, the real wage.

Plant-level employment in production satisfies the static condition for labor, for $j = 1..J_s$:

$$n_{j,t,C} = \left(\frac{v A_t k_{j,t,C}^{\gamma}}{w_t} \right)^{1/(1-v)}, \tag{1.15}$$

$$n_{j,t,K} = \left(\frac{p_t v A_t k_{j,t,K}^{\gamma}}{w_t} \right)^{1/(1-v)}. \tag{1.16}$$

Each plant in both sector hires labor until the marginal product of labor is equal to the real wage. The remaining efficiency conditions describe optimal adjustment fractions and target capital choice. The finite upper support for the cost CDF, combined with a constant rate of depreciation makes investment increasingly valuable across vintages. This result greatly simplifies the state space of the model, the economic history is redundant beyond a finite number of lags. Once the capital stock has depreciated enough, the value of investing offset the highest possible fixed cost. In equilibrium, there exists in each sector an endogenously chosen vintage J_s at which full adjustment occurs: $\alpha_{J_s,t,s}$ =1. In each sector, for $j_s < J_s$, optimal fraction of adjusting are interior solutions equating the anticipated value of adjusting one additional plant from group j to the additional cost entailed, $w_t G^{-1}(\alpha_{j,t,s})$ in units of output, and investment required. For each $j_s = 0..J_s - 1$:

$$v_{0,t,s} - v_{j+1,t,s} = p_t i_{j,t,s} + \ w_t G^{-1}(\alpha_{j,t,s}), \tag{1.17}$$

$$\begin{aligned} v_{j,t,C} \quad &= \quad E_t \ (\beta \frac{\lambda_{t+1}}{\lambda_t} (y_{j,t+1,C} - w_t n_{j,t+1,C} - \alpha_{j,t+1,C} p_{t+1} i_{j,t+1,C} + \\ &\quad \alpha_{j,t+1,C} v_{0,t+1,C} + (1 - \alpha_{j,t+1,C}) v_{j+1,t+1,C} - w_t \Xi(\alpha_{j,t+1,C})), \end{aligned} \tag{1.18}$$

$$\begin{aligned} v_{j,t,K} \quad &= \quad E_t \ (\beta \frac{\lambda_{t+1}}{\lambda_t} (p_{t+1} y_{j,t+1,K} - w_t n_{j,t+1,K} - \alpha_{j,t,C} p_{t+1} i_{j,t+1,K} + \\ &\quad \alpha_{j,t+1,K} v_{0,t+1,K} + (1 - \alpha_{j,t+1,K}) v_{j+1,t+1,K} - w_t \Xi(\alpha_{j,t+1,K})), \end{aligned} \tag{1.19}$$

where $v_{0,t,C}$ is the multiplier on the constraints for the target capital in the consumption sector (1.4) and it represents the marginal value of having one more plant with the target level of capital next period. $v_{j+1,t+1,C}$ is the multiplier on the constraints (1.5) in the consumption sector and represents the marginal value of having one more plant in the vintage $j+1$ next period. The value of the multipliers $v_{j,t,C}$ and $v_{j,t,K}$ are defined in equation (1.18) and (1.19). Plants in the consumption sector sell their output (the consumption good) at a price normalized to 1, and plants in the investment sector sell their output at p, the relative price of investment relative to the consumption good. There will be a marginal firm for which equation (1.17) holds with equality that identifies $\alpha_{j,t+1,C}$ and $\alpha_{j,t+1,K}$, the fraction of plants for given vintage j that decides to invest and can be interpreted as hazard rates. $\alpha_{j,t+1,C}$ and $\alpha_{j,t+1,K}$ are increasing in j, the number of periods of inaction of a plant. The higher the distance between the target and the actual capital, the higher the probability for a plant to invest.

Sectoral capital allocation is subject to the following efficiency conditions:

$$\mu_{0,t,C} = p_t, \tag{1.20}$$

$$\mu_{0,t,K} = p_t, \tag{1.21}$$

$$\mu_{0,t,C} = E_t\, (\beta \frac{\lambda_{t+1}}{\lambda_t} (MPK_{0,t+1,C} + (1-\delta)(1-\alpha_{0,t+1,C})\mu_{1,t+1,C} + (1-\delta)\alpha_{0,t+1,C}\; p_{t+1}), \tag{1.22}$$

$$\mu_{0,t,K} = E_t\, (\beta \frac{\lambda_{t+1}}{\lambda_t} (p_t MPK_{0,t+1,K} + (1-\delta)(1-\alpha_{0,t+1,K})\mu_{1,t+1,K} + (1-\delta)\alpha_{0,t+1,K}\; p_{t+1}). \tag{1.23}$$

Equations (1.20) and (1.21) govern the installation of new capital in each sector, the investment good is allocated to each sector until $\mu_{0,t,C}$, the expected marginal value of installing an additional unit of capital in the consumption sector, defined by equation (1.22) and $\mu_{0,t,K}$, the expected marginal value of installing one additional unit in the investment sector, defined by equation (1.23), are equal to p_t, the relative price of an additional unit of capital. $MPK_{j,t,s}$ indicates marginal productivity of capital and $\mu_{j,t,s}$ denotes the marginal value of an additional unit of capital in vintage j.

When the upper support of the distribution of the idiosyncratic shock in each sector, B_C and B_K are set to zero, the planner problem boils down to a two-sector neoclassical model with two representative firms; one producing the consumption good and one producing the investment good as in Dow and Olson (1992). I refer to this model as frictionless. I also consider a model with a different specification: convex costs of capital adjustment [2].

1.4 Model Solution and Calibration

In this section I describe the algorithm used to solve the model, and the parameterization chosen. The computation of the steady state of the modelrequires a numerical procedure because J_C and J_K, maximum time-since-adjustment in the consumption and in the investment sector, are endogenously determined. The solution algorithm is the following. I guess the target capital in both sector $k_{0,C}$ and $k_{0,K}$, the relative price of investment p, and the fraction of plants investing for each level of capital $\boldsymbol{\alpha}_{j,C}$ and $\boldsymbol{\alpha}_{j,K}$ and the wage w. It is then possible to solve the entire model. I use equations (1.9), (1.15), (1.20), (1.21), (1.18) and (1.19), to verify and update the guess. I iterate this procedure until $\alpha_{JC,t}$ and $\alpha_{JK,t}$

[2] Convex adjustment costs are assumed to be quadratic, see Appendix 1 for details on the equations of the model.

are equal to 1, (i.e. plants with level of capital k_{JC} and k_{JK} adjust with probability 1).

The calibration of the parameters of the model is summarized in table 1 and it mostly follows Thomas (2002). The momentarily utility function is $u(C_t, 1 - N_t) = log(C_t) + \zeta N_t$. Labor is indivisible as in Hansen (1985). The value of ζ is set to 3.614. The depreciation rate (δ) is the same in the two sectors and it is set to 0.06, implying an investment to capital ratio equal to 7.6% (Cooley and Prescott 1995). The discount factor in the utility function (β) implies a real interest rate of 6.5% given the long-run per capita output growth of 1.6% as in King and Rebelo (King and Rebelo). The parameters of the production function γ and ν are respectively set to 0.31 and 0.58. The persistence of the aggregate productivity shock ρ is set equal to 0.98, while in Thomas (2002) is 0.92. Results are robust to this assumption. When ρ is equal to 0.92, in response to the shock consumption follows a non-monotonic declining pattern while it follows a hump-shaped response when productivity is equal to 0.98[3]. The response of investment is the same in the two cases.

The shape and the upper support of the distributions of the fixed cost differ from Thomas (2002).

In Thomas (2002) the idiosyncratic component of the fixed cost is drawn from a uniform distribution and the upper support is chosen to match two facts in Doms and Dunne (1998): in an average year 8% of plants raise their real capital stock by 30% or more, and these plants represent 25% of aggregate investment.

Here, I choose to calibrate the shape and the upper support of the distribution to be consistent with results in Gourio and Kashyap (2007). Variations in aggregate investment are driven by variations in the number of plants undergoing investment spikes. In the

[3] The same result occurs in Carlstrom and Fuerst (1994).

data the variance of aggregate investment accounted by investment spikes is 97% and the contribution of the extensive margin to the increase in spikes is 87%[4].

The probability density function of the idiosyncratic fixed cost is the same across sectors:

$$F(\omega, \chi, \pi) = 1 - (1 - (\frac{\omega}{B_s})^{\chi})^{\pi}, \text{and } \omega \ \epsilon \ [0, B_s], \ \ s = C, K. \tag{1.24}$$

The parameter χ is set to 3 and π is set to 2. See the plot of the probability density function (PDF) and the CDF in figure 1 and figure 2. When χ and π are both set to 1, the distribution is uniform. The upper support for the consumption sector, B_C, is set to 0.018 and B_K, the upper support for the investment sector is set to 0.006. Results are robust to different parameterization of the CDF and of the upper support of the idiosyncratic shock distribution. The frictionless model follows the calibration of the lumpy model with B_C and B_K both set to zero. The same is true for the quadratic adjustment cost model[5] with φ, the parameter measuring the convexity of capital adjustment cost function, set equal to 0.1.

[4] The calibration in Thomas (2002) is not consistent with findings in Gourio and Kashyap (2007). In Thomas' model the variance of aggregate investment accounted by investment spikes is 51% and the contribution of the extensive margin to increase in spikes 62%. Gourio and Kashyap (2007) show that lumpy investment irrelevance does not depend upon the calibration.

[5] The quadratic adjustment cost function $\frac{\varphi}{2}(\frac{I_t - T_K \delta}{K_t})^2 K_t$.,where T_K is the growth rate of capital along the balanced growth path and K_t is the stock of capital at the beginning of the period.. Adjustment costs are therefore zero along the balanced growth path.

1.5 Results

1.5.1 Steady State

In steady state the 9% of the plants has spikes and accounts for roughly 90% of the aggregate investment in each period. In figure 1, I plot the steady state distribution for the consumption and the investment sector. Hazard rates in each sector increase with distance between target and actual capital. Along the balanced growth path, the average fixed cost paid in each sector is equal to 1.55% for the consumption sector and 1.63% for the investment sector. The size of the fixed cost is therefore small compared to the value of 7.5% estimated in Cooper and Haltiwanger (2006) but it is inside the range of 1.1%-9.7% estimated by Abel and Eberly (2002). In steady state the 9% of the plants has spikes and accounts for roughly 90% of the aggregate investment in each period. Table 2 reports the business cycle statistics of the three economies. Aggregate investment is more volatile in the frictionless model while in the lumpy model is more volatile than the quadratic adjustment cost case. The differences in absolute and relative volatility of hours worked mirror the one for investment. The relative and absolute volatilities for consumption are almost identical.

1.5.2 Business Cycle Dynamics

I analyze the business cycle dynamics of the frictionless, lumpy and quadratic model in response to an aggregate productivity shock. I take a log-linear approximation around the non-stochastic steady state.

In the lumpy mode, the relevant margin of variation in aggregate investment is the extensive one. In the data, the percentage of the investment rate variance accounted by variations in investment spikes at plant level is 99%. Moreover, variations in spikes driven by the extensive margin (Share ADJ20) are 87%. These two numbers are respectively 97% and 92% in the lumpy investment model[6]. Statistics on measure of lumpiness along the cycle are reported in table 3.

I now turn to the aggregate consequences of microeconomic lumpiness and I compare them to a frictionless neoclassical benchmark and without capital adjustment costs. In all models, when the shock hits the economy the shadow value of capital increases. The planner wants to increase the stock of capital in the investment sector to augment the production of the investment good. On impact, in the frictionless case, reallocation of the investment good from the consumption to the investment sector results in a spike of investment in the investment sector. In following periods, over time a higher fraction of investment is allocated to the production of the consumption good while a smaller one is allocated to the investment sector. Aggregate investment has a spike in the period following the shock and then monotonically decline to the steady state level.

In the lumpy model, the fixed cost faced by plants in both sectors first slows down the reallocation of the investment good across sectors and then results in an amplification of aggregate investment relative to the frictionless case, as shown in figure 2. The build-up of capital in the investment sector, that occurs on impact in the frictionless case, is much more gradual. Less investment goods are produced and the relative price of investment is higher relative to the frictionless case. In the consumption sector, as a consequence, depreciated capital is not replaced as plants forgo investment. The decrease in the number of adjusters

[6] Results are obtained simulating the model 1,000 times for 200 periods.

in the consumption sector, see the plot of $\vartheta_{0,t,C}$ in figure 3, results in a shift of firms to the right part of the distribution with higher capital imbalances and increasing hazard rates. A large capital imbalance today combined with increasing likelihood of investing in the future generates an amplification of aggregate investment relative to the frictionless case.

In the convex capital adjustment cost model, instead, the response of aggregate investment is muted relative to the non-convex case. When the adjustment cost function is convex, upward and downward variations of sectoral stock of capital, relative to the steady state level, are subject to an adjustment cost. Decrease capital in the consumption sector is costly as it is the build-up in the investment sector.

Note that the differences between the convex and non-convex adjustment cost do not depend on the magnitude of φ, the parameter measuring the convexity of capital adjustment cost function. Increasing φ dampens even more the response of aggregate investment, while the lower φ the closer the response of aggregate investment to the frictionless case.

Aggregate consumption follows a hump-shaped response in all the three cases considered. As for total investment, the case with lumpiness result in a late amplification compared to the frictionless case and quadratic adjustment cost case. This depends upon the slower capital accumulation in the consumption sector. Total output follows a hump-shaped response in all the three setups. The response in the lumpy case again is amplified relative to the other two cases, the peak response of output occurs four periods after the shock.

Total labor exhibits a hump-shaped response in the case of fixed cost, mimicking the behavior of aggregate investment and resulting in a late amplification. Aggregate productivity leads the peak in the response of total hours. The target level of capital $k_{0,t+1,C}$ increases gradually while $k_{0,t+1,K}$ spikes on impact and then monotonically decline to the steady state.

1.5.3 Comparison with Related Literature

The previous subsection shows that microeconomic lumpiness, when introduced in a two sector model, yields different quantity dynamics from standard neoclassical models. Specifically, microeconomic lumpiness generates spikes at sectoral level with smooth aggregate, accounting simultaneously for microeconomic and macroeconomic investment behavior. Results are in contrast with previous literature. In a one-sector economy, Thomas (2002) finds that accounting for lumpiness is irrelevant for aggregate investment. General equilibrium effects (i.e. price movements) wash out in the aggregate non-convexities at plant level due to households' preferences for smooth consumption profiles. The relevance of lumpiness in a two-sector model is linked to the limited intersectoral mobility of capital induced by non-convex costs of capital adjustment. In a two-sector model, such a friction affects the total costs of investment not only through the adjustment cost, but has also an effect on the relative price of investment. Limited reallocation of capital induced by the fixed costs at sectoral level impacts the relative price of investment and as a consequence the dynamics of aggregate investment. In a one-sector model with lumpiness, as the one in Thomas (2002), this mechanism is absent. Capital mobility is perfect across sectors and adjustment costs have no impact on the relative price of investment. The assumption of costly reallocation of resources across sectors captures capital sectoral specificity consistent with empirical evidence in Ramey and Shapiro (2001)[7].

[7] They use equipment-level data from aerospace plants to study the process of moving installed physical capital to a new use. Their results suggest significant sectoral specificity of physical capital and substantial

House (2008) analyzes a one-sector economy with lumpy investment and shows that for sufficiently lived capital, the intertemporal elasticity of investment is nearly infinite, and concludes that the "irrelevance result" is not a special case but a fundamental property of the economy. However, this is not the case in a two-sector framework. Even if the investment demand with non-convex cost of adjusting the level of capital is nearly flat, lumpy investment is relevant. The supply of the investment good is subject to adjustment cost and therefore it moves gradually relative to the frictionless neoclassical case. The increase in the equilibrium quantity of the investment good produced is gradual rather than resulting in a spike as in the frictionless case. Moreover, introducing convex costs of capital adjustment does not replicate the result obtained with convex-costs. The convex adjustment cost function symmetrically penalizes upward and downward adjustment dampening the response of aggregate investment relative to the lumpy case.

Bachmann et al. (2006) build a model with lumpiness, maintenance investment, heterogeneity in productivity and, a continuum of sectors. They do not consider link input-output across sectors . They find that lumpy investment is relevant with nearly-risk neutral households. Difference in the response of aggregate investment between the frictionless and the lumpy case appear at longer frequency than in setup considered in here.

1.5.4 Investment Shock

In this section, as a robustness check for the results obtained in section 5.2, I analyze the dynamic properties of the two-sector model with lumpiness in response to an investment

costs of redeploying the capital.

specific shock, and I compare them with neoclassical benchmarks without adjustment costs and with convex costs of capital adjustment. The exercise is motivated by results in Greenwood et al. (2000) and Christiano and Fisher (2003) who show that investment specific shocks are an important source of cyclical fluctuations. The three models compared have the same calibration as in section 4. The productivity shock hits only the investment sector. Results are similar to the ones obtained with a neutral productivity shock and therefore are not reported. Findings are in contrast with Khan and Thomas (2003), who find that the irrelevance result to apply also when the source of fluctuations in the economy is an investment specific shock. The reason of the difference is the impact of non-convex adjustment cost on the relative price of investment.

1.6 An Empirical Test of the Lumpy Model

The lumpy model predicts that aggregate dynamics of investment are affected by movements in the sectoral distributions. Gourio and Kashyap (2007) show that variation in aggregate investment are mainly driven by variation in the number of establishments undergoing investment spikes: the extensive margin. Using annual 2-digit SIC industry data[8], I evaluate the empirical relevance of measures of sectoral distribution in predicting aggregate investment, while they focus on measure of distribution constructed looking at the entire manufacturing. I follow the specification used in Gourio and Kashyap (2007) :

$$\frac{Itot_t}{K_{t-1}} = \alpha + \beta \frac{Itot_{t-1}}{K_{t-2}} + \gamma \frac{Sales_{t-1}}{K_{t-2}} + \sum_{s=1}^{Ji} \delta_i ADJ20_{t-r,s} + trend \ . \tag{1.25}$$

[8] I do not have access to the underlying plant-level but only to aggregation based on their investment rate. See Appendix 2 for details.

The response of aggregate investment rate $(\frac{Itot_t}{K_{t-1}})$ for the manufacturing sector, obtained as total investment of manufacturing divided by initial period level of capital, is regressed on lagged measures of the distribution controlling for past investment rate and past sales, measured as total value of shipments. $ADJ20$ represents the fraction of capital that experiences a spike in investment rate, defined as an investment rate above 20%. I disaggregate their measure to be consistent with the theoretical model. I construct the same measure for two broadly defined sectors, using the input-output table from Bureau of Economic Analysis. I assign each industry to the consumption sector or to the investment sector based on the destination of their output. If the output of the industry is a final (investment) good the industry is assigned to the consumption (investment) sector (see table 6 for details). There are three industries that do not have a clear-cut assignation, I assign them to a third sector called consumption/investment sector and I use it for robustness analysis. Consumption and investment sector almost mirror the distinction between non-durable and durable goods. $ADJ20\_cons$, $ADJ20\_inv$ and $ADJ20\_coninv$ are the fraction of capital in the consumption, investment and the third sector that experiences a spike in investment rate. The estimation method is ordinary least squares (OLS) with corrected standard errors using Newey and West (1987) procedure.

Table 7 reports the results. In column 1 and 2, I replicate the findings in Gourio and Kashyap (2007). The coefficients on lags of $ADJ20$ are negative and significant at 1% and 5% level of significance: a surge in investment in the current period, results in a lower investment next period. In column 3, only one lag of each sectoral distribution is considered. The coefficients are both negative, but only the one on the investment sector is significant. In column 4, two lags of both sectoral distributions are considered. The coefficient of the first lag of $ADJ20\_cons$ is negative and significant at 5% level. Both lags are jointly and as a sum significant at 1% level. Lags of $ADJ20\_inv$ are jointly significant at 1% level and their sum as well. As a control I also include in column 5 and 6, $ADJ20\_coninv$ which is never significant as a sum nor jointly. Variations in the number of establishments undertaking spikes in broadly identified sectors can forecast aggregate investment. The magnitude of the coefficients is the same in the consumption and in the investment sector but the quantitative implications of the estimated coefficients differ. An increase of one standard deviation in $ADJ20\_cons$, equal to 0.03, results in a decrease of investment of around 0.6%. An increase of one standard deviation in $ADJ20\_inv$, equal to 0.06 results in a decrease of investment of 1.1%. They indicate heterogeneity on the role of sectoral distribution in shaping the dynamics of aggregate investment[9].

To verify the consistency of these empirical findings with the two-sector lumpy model, I perform 1,000 simulations for 200 periods, when the source of fluctuations in the economy is a neutral productivity shock. In each of the simulation I estimate the specification in (1.25) with one and two lags of $ADJ20\_cons$ and $ADJ20\_inv$. When only one lag of the sectoral distribution is included, the average coefficient of $ADJ20\_cons$ is -.28 and the one of $ADJ20\_inv$ is -.06. Both are significant at 1% level. With two lags, the average coefficients of $ADJ20\_cons$ are -.13 and -.15 while the ones of $ADJ20\_inv$ are -.03 and -0.04. All the coefficients are significant at least at 5% level. The coefficients are similar in magnitude to the ones estimated manufacturing data. The results obtained with sectoral data are consistent with the one generated by a two-sector model with non-convex capital adjustment cost. The empirical analysis is suggestive that variations in the distribution of

[9] I use the result in column 4 to perform this exercise.

capital are quantitatively relevant for explaining aggregate investment (of the manufacturing sector).

1.7 Final Remarks

This paper explores the aggregate consequences of a model that accounts for lumpy investment at plant level with sectoral specificity of capital. I analyze the dynamics of aggregate investment after a neutral and an investment specific productivity shock. The model generates different predictions on aggregate investment relative to benchmark neoclassical cases. The lumpy case results in an amplification of aggregate investment relative to the neoclassical benchmarks. The two-sector lumpy model is able to simultaneously account for microeconomic evidence on lumpy investment and gradual response of aggregate investment consistent with VAR evidence in Christiano et al. (2004). Contrary to previous literature, non-convexities at the plant level survive general equilibrium analysis. The reason lies on how convex costs of capital adjustment affect the relative price of investment, limiting intersectoral mobility of capital.

The theoretical predictions of the model rehabilitate the role of non-convexities at plant level as an important determinant for aggregate investment. Empirical results confirm the theoretical predictions of the model and suggest that lumpy investment is relevant for the business cycle.

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1.8 APPENDIX 1

This appendix describes the planner's problem in a two sector model when sectoral investment is subject to convex adjustment costs.

The planner maximizes the discounted sum of utility with respect to consumption:

$$\max_{C_t, I_{t,i}, K_{t,s}, N_{t,C}, N_{t,K}} \left[\sum_{s=0}^{\infty} \beta E_{t+s} u(C_{t+s}, 1 - N_{t+s}) \right] \tag{A.1}$$

subject to the following constraints

$$C_t = A_t K_{t-1,C}^{\gamma} N_{t,C}^{\nu} , \tag{A.2}$$

$$\begin{aligned} K_{t,C} + K_{t,K} = {} & A_t K_{t-1,K}^{\gamma} N_{t-1,K}^{\nu} +, (1-\delta)(K_{t-1,C} + K_{t-1,K}) + \\ & \frac{\phi}{2} \left(\frac{K_{t,C} - T_K K_{t-1,C}}{K_{t-1,C}} \right)^2 K_{t-1,C}. + \frac{\phi}{2} \left(\frac{K_{t,K} - T_K K_{t-1,K}}{K_{t-1,K}} \right)^2 K_{t-1,K}. \end{aligned} \tag{A.3}$$

$$N_t = N_{t,C} + N_{t,K} \tag{A.4}$$

$K_{t-1,C}$ and $K_{t-1,K}$ denote the beginning of period stocks of capital in the consumption and investment sectors, respectively. Similarly, $N_{t,C}$ and $N_{t,K}$ refer to hours worked in the consumption and investment-good sectors, while N_t denotes total labor worked. T_K denotes the growth rate of capital along the balanced growth path.

1.9 APPENDIX 2

This Appendix briefly describes the data used in the empirical exercise. These data were provided by Shawn Klimek of the Census of the Bureau and and François Gourio for providing the data. The capital expenditure data are taken from the Census' Bureau Annual Survey of Manufactures (ASM). Details of the construction can be found in Becker et al. (2005). Their core calculation involves building up a capital stock series using a perpetual inventory method. Establishments are sorted based on their investment rate for each period. By summing across categories I get all the variables of interest for each year. The sample runs from 1974 to 1998.

Table 1				
Calibration Parameters				
β	ζ	BC	BK	σ^2
0.954	3.6142	0.018	0.006	0.0134
ρ	γ	ν	δ	φ
.98	0.31	0.58	0.06	0.1

Table 2				
Standard Deviations				
	Output	Consumption	Investment	Employment
Data	1.81	1.35	5.3	1.79
Frictionless	1.52	1.13	3.07	0.45
Lumpy	1.49	1.13	2.74	0.42
Quad adj cost	1.47	1.14	2.47	0.35

Table 3			
	corr(Y,C)	corr(Y,I)	corr(Y,N)
Data	0.88	0.80	0.88
Frictionless	0.98	0.93	0.88
Lumpy	0.98	0.93	0.87
Quad Adj cost	0.99	0.96	0.94

Table 4				
Standard Deviations Relative To Output				
	Output	Consumption	Investment	Employment
Data	*	0.74	2.93	0.99
Frictionless	*	0.74	2.01	0.30
Non-convex adj. cost	*	0.76	1.83	0.28
Convex adj. cost	*	0.74	1.63	0.23

Table 5				
Steady State	data	Lumpy Model	Cons sector	Inv sector
J	NA	23	23	23
Total Adj. Cost/Tot Inv	NA	1.44%	1.43%	1.48%
Mean % Plants I/K > 20%	20.8%	9.6%	9.9%	8.9%
Mean I20/Itot	49.9%	93.12%	92.9%	93.8%
% Variance of Itot/K due to I20/K	97%	99.9%	99.9%	99.9%
SHARE ADJ20	87%	92.09%	94.13%	87.13%
Share ADJ20 is the fraction of variance in spikes (I20/K) due to variation in the number of establishments experiencing spikes				

Table 6		
Sector	Industry name	2-digit SIC Code
Investment	Lumber and Wood Products	24
Investment	Industrial Machinery and Equipment	35
Investment	Instruments and Related Products	38
Consumption	Food and Kindred Products	20
Consumption	Textile Mill Products	22
Consumption	Apparel and Other Textile Products	23
Consumption	Printing and Publishing	27
Consumption	Chemical and Allied Products	28
Consumption	Rubber and Miscellaneous Plastic Products	30
Consumption	Primary Metal industries	33
Consumption	Misc. Manuf. Industries	39
Consumption/Investment	Furniture and Fixtures	25
Consumption/Investment	Fabricated Metal Products	34
Consumption/Investment	Electronic and other Electric Equipment	36

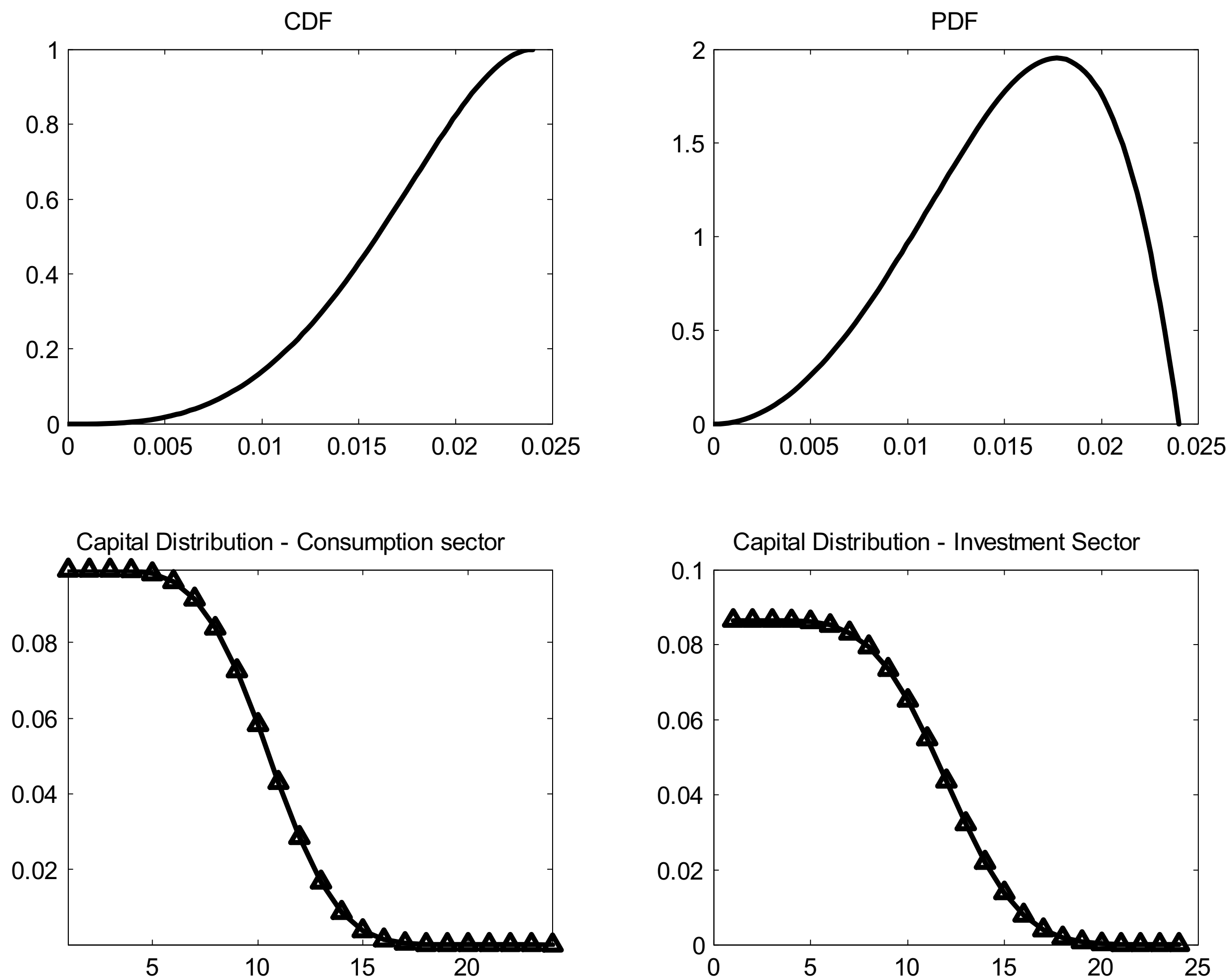


Figure 1. Top panels report the CDF and the PDF of the idiosyncratic fixed cost shock. Lower panels plot the capital distribution in each sector. The horizontal axis represents time-since-adjustment and the vertical axis the fraction of firms with each vintage.

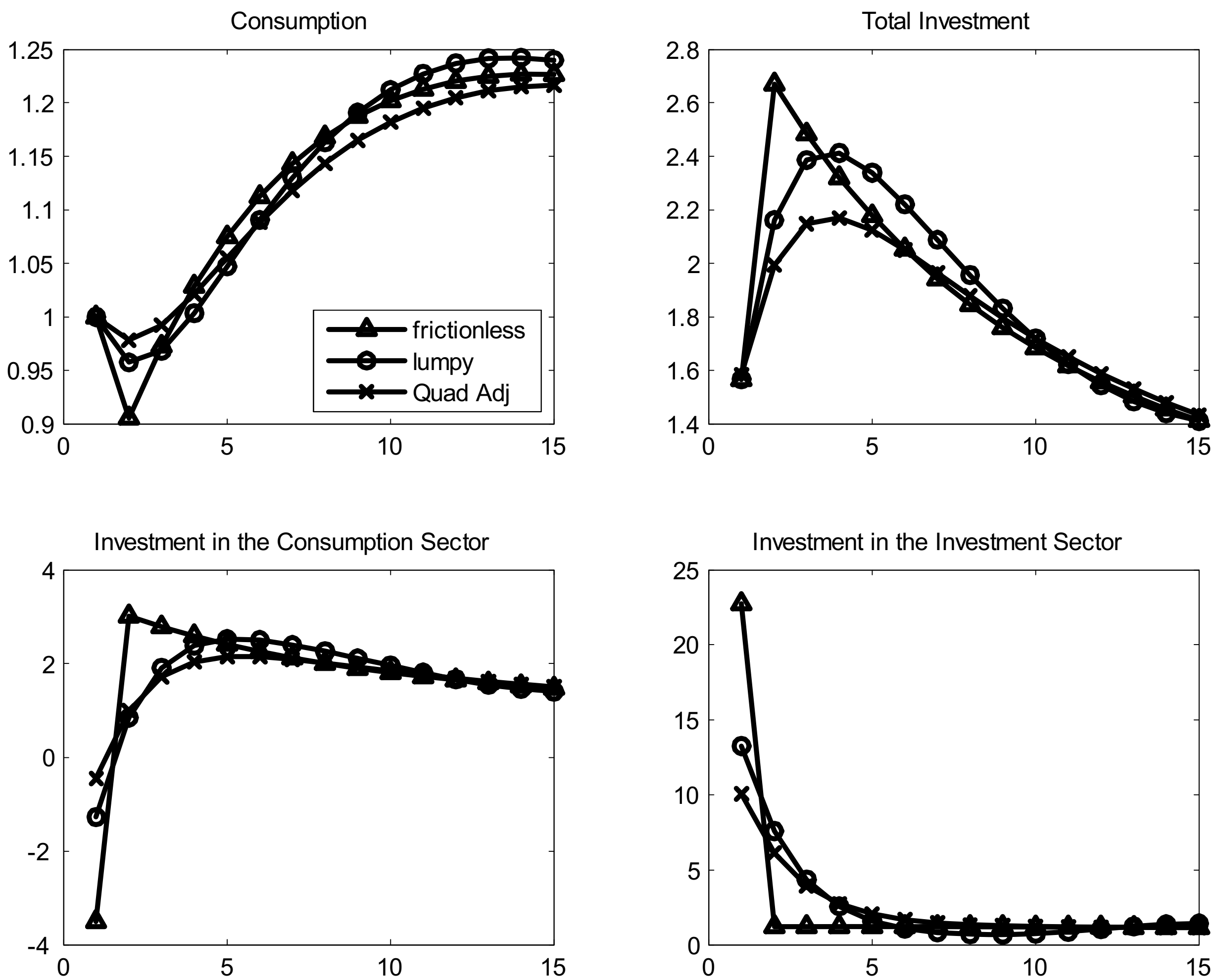


Figure 2: Impulse responses to an aggregate productivity shock in the lumpy model, frictionless and with quadratic adjustment costs.

Note: The y-axis measures percentage deviations from the steady state.

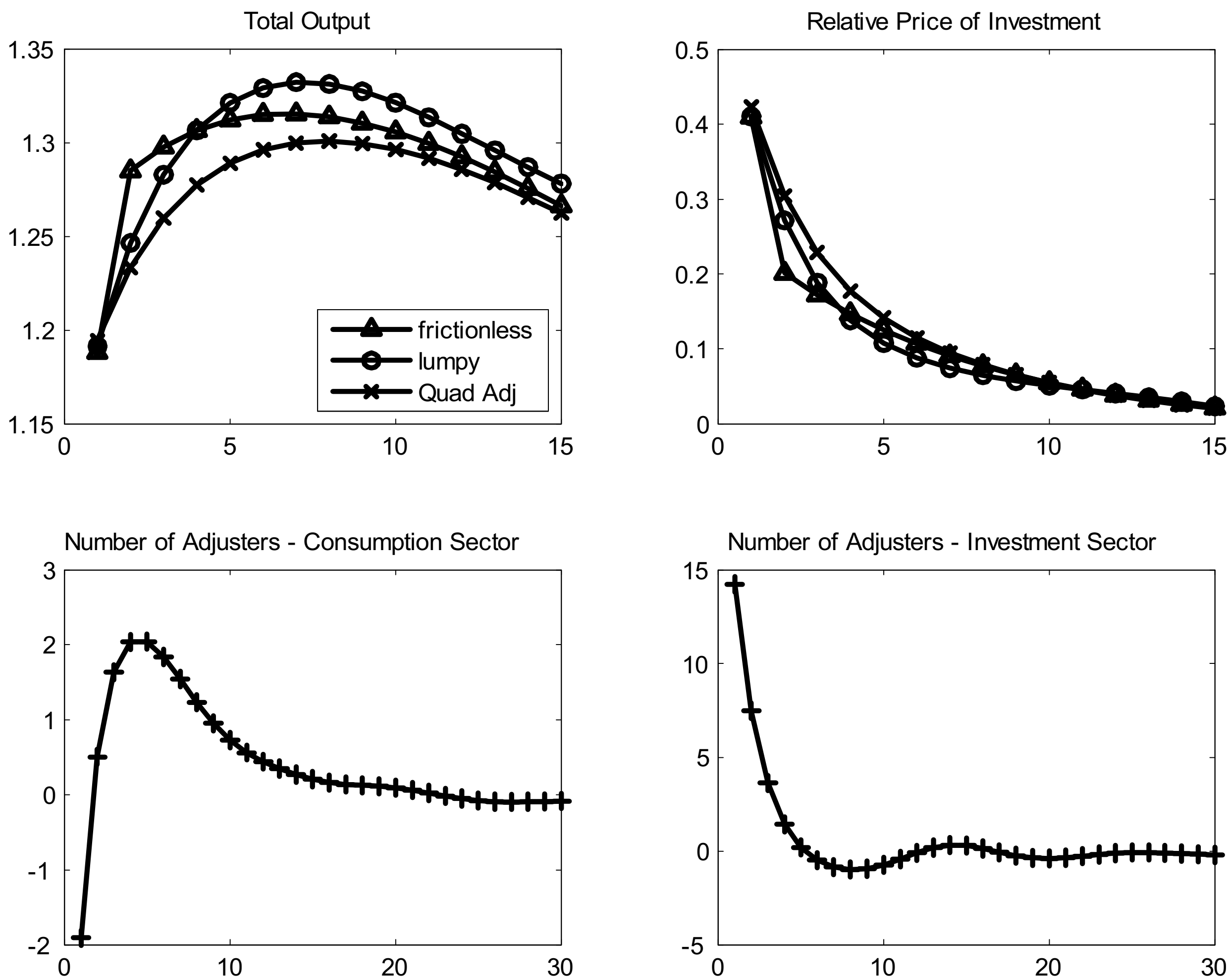


Figure 3: Impulse responses to an aggregate productivity shock in the lumpy model, frictionless and with quadratic adjustment costs. Lower panels plot the response of the number of adjusters $\vartheta_{0,t,C}$ and $\vartheta_{0,t,K}$. Note: The y-axis measures percentage deviations from the steady state.

	(1) I/K(-1)	(2) I/K(-1)	(3) I/K(-1)	(4) I/K(-1)	(5) I/K(-1)	(6) I/K(-1)
L.I/K(-1)	1.227***	1.448***	1.095***	1.345***	1.128***	1.432***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.S/K(-1)	0.0107	0.00708	0.0248*	0.0218	0.0258*	0.0163
	(0.361)	(0.523)	(0.093)	(0.140)	(0.091)	(0.337)
L.ADJ20	-0.218***	-0.234***				
	(0.001)	(0.000)				
L2.ADJ20		-0.126**				
		(0.038)				
L.ADJ20 CONS			-0.0489	-0.180**	-0.0636	-0.191**
			(0.527)	(0.032)	(0.437)	(0.021)
L2.ADJ20 CONS				0.00425		-0.0188
				(0.964)		(0.867)
L.ADJ20 INV			-0.116***	-0.0781	-0.0932**	-0.0784
			(0.000)	(0.199)	(0.024)	(0.261)
L2.ADJ20 INV				-0.0813		-0.0537
				(0.166)		(0.520)
L.ADJ20 CONINV					-0.0283	-0.00372
					(0.401)	(0.923)
L2.ADJ20 CONINV						-0.0237
						(0.592)
N	24	23	24	23	24	23
Joint		0.000422				
Sum		0.000213				
Joint_cons				0.00202		0.000715
Sum_cons				0.00272		0.00497
Joint_inv				0.00000233		0.0208
Sum_inv				0.000000560		0.0103
Joint_coninv						0.767
Sum_coninv						0.485

p-values in parentheses where * p<0.10, ** p<0.05, *** p<0.01. ADJ20 represents the fraction of plants undergoing a spike for each sector. L. stands for the first lag and L2 stands for the second lag. The dependent variable is aggregate investment rate. Equations are estimated by OLS, standard errors corrected using Newey-West procedure. Joint and Sum reports the p-value of testing respectively the joint significance of both lags and their sum.

	(1)	(2)	(3)	(4)	(5)	(6)
	I/K(-1)	I/K(-1)	I/K(-1)	I/K(-1)	I/K(-1)	I/K(-1)
L.I/K(-1)	1.227***	1.448***	1.095***	1.345***	1.128***	1.432***
	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
L.S/K(-1)	0.0107	0.00708	0.0248*	0.0218	0.0258*	0.0163
	(0.361)	(0.523)	(0.093)	(0.140)	(0.091)	(0.337)
L.ADJ20	-0.218***	-0.234***				
	(0.001)	(0.000)				
L2.ADJ20		-0.126**				
		(0.038)				
L.ADJ20 CONS			-0.0489	-0.180**	-0.0636	-0.191**
			(0.527)	(0.032)	(0.437)	(0.021)
L2.ADJ20 CONS				0.00425		-0.0188
				(0.964)		(0.867)
L.ADJ20 INV			-0.116***	-0.0781	-0.0932**	-0.0784
			(0.000)	(0.199)	(0.024)	(0.261)
L2.ADJ20 INV				-0.0813		-0.0537
				(0.166)		(0.520)
L.ADJ20 CONINV					-0.0283	-0.00372
					(0.401)	(0.923)
L2.ADJ20 CONINV						-0.0237
						(0.592)
N	24	23	24	23	24	23
Joint		0.000422				
Sum		0.000213				
Joint_cons				0.00202		0.000715
Sum_cons				0.00272		0.00497
Joint_inv				0.00000233		0.0208
Sum_inv				0.000000560		0.0103
Joint_coninv						0.767
Sum_coninv						0.485

p-values in parentheses where * $p<0.10$, ** $p<0.05$, *** $p<0.01$. ADJ20 represents the fraction of plants undergoing a spike for each sector. L. stands for the first lag and L2 stands for the second lag. The dependent variable is aggregate investment rate. Equations are estimated by OLS, standard errors corrected using Newey-West procedure. Joint and Sum reports the p-value of testing respectively the joint significance of both lags and their sum.

Chapter 2

Employment Outcomes and the Interaction Between Product and Labor Market Deregulation: Are They Substitutes or Complements?

2.1 Introduction - (joint with G. Nicoletti, S. Scarpetta and F. Schiantarelli)

Over the past two decades, many OECD countries have sought to promote productivity and long term growth by improving the efficiency of goods and services markets through liberalization and privatization. There is a growing body of evidence suggesting that these processes have indeed boosted productivity performances in the sectors concerned, but less is known about their consequences on employment.[1] A few recent theoretical and empirical

[1] See Schiantarelli (2005), Nicoletti and Scarpetta (2006) and Crafts (2006) for a review of the cross country evidence.

studies suggest that product market deregulation may also stimulate aggregate employment, yet robust conclusions are still lacking.[2] In assessing the effect of regulatory reform of product markets it is crucial to take into account that this policy has been implemented in countries with very different labor market settings. This raises two related questions. First, do the employment gains from product market deregulation depend upon the underlying labor market policies and institutions that shape the bargaining power of workers and, if so, how? Second, do reforms that promote stronger product market competition lead to changes in labor market policies and institutions?

While the effects on employment outcomes of labor market policies, and the interactions between various measures, have been explored extensively, less work has been done on the employment effects of interactions between product and labor market policies.[3] Moreover, the predictions about these interactions often are not based on fully specified theoretical models and the empirical results, obtained mostly from estimating static equations, have differed widely across studies. While, for instance, Nicoletti and Scarpetta (2005), Griffith et al. (2007), and Amable et al (2007) find that product market deregulation is more effective at the margin in highly-regulated labour markets, Berger and Danninger (2006) and Bassanini and Duval (2006) find the opposite: product market deregulation is more effective when labor market policies are less restrictive. Robust evidence is still lacking, especially in the context of dynamic econometric models that control for the many observed

[2] Theoretical models include Blanchard and Giavazzi (2003), Spector (2002), Amable and Gatti (2001), Ebell and Haefke (2003) and Koeniger and Prat (2006).

[3] Interactions between labor market policies have been explored, for instance, by Saint-Paul (2000) and Belot and van Ours (2004). See Nickell, Nunziata and Oechl (2005) and Blanchard (2006) for an overview of the effects of labor market policies, shocks and institutions on unemployment. For micro evidence on the employment effects of entry regulation see also Bertrand and Kramarz (2002). For additional macro evidence see Boeri et al. (2000).

and unobserved factors that determine employment. Moreover, none of these empirical analyses accounts for the fact that policies in labour and product markets are not exogenous to macroeconomic shocks and may interact with each other, for instance because the power of unions to lobby for restrictive labor market policies may change as competitive pressures in product markets increase due to deregulation.

In this paper we address several of the limitations of previous empirical research in this area and we provide a systematic empirical investigation of the effect of product market liberalization on employment when there are interactions and political economy linkages between policies and institutions in product and labour markets. The empirical analysis is grounded in an extended version of Blanchard and Giavazzi '(2003) model of bargaining in a monopolistic competitive economy, in which we allow a fuller specification of the fall-back position of the union, taxation and endogenous determination of bargaining power. In our econometric work we use a dynamic specification of the employment rate equation that includes both country specific constants and trends, and we explicitly account for the potential endogeneity of labour and product market policies and for the possible interactions in their determination. We show that this helps understanding some of the conflicting results of the previous literature on policy interactions, while providing a more detailed picture of the channels through which they affect employment.

We first extend the model of bargaining and monopolistic competition developed by Blanchard and Giavazzi (2003), by including a fuller specification of the fallback position of the union as well as taxation in the model.[4] Treating initially product market regulation

[4] Some authors have contended that a high tax wedge on labour use is an important factor behind the difference in the level of unemployment in Europe vis a vis the US in the nineties. On these general issues see Daveri and Tabellini (2000) and Prescott (2004).

and labor market regulation as set exogenously and independently from one another, the model suggests that employment gains from product market deregulation are the largest in situations where labor market settings provide strong bargaining power to workers. The basic intuition behind this result is that, with low unions' bargaining power, real wages will be close to the level that clears the labor market and employment close to its full employment level. In this case, liberalization measures that lead to a decrease in the markup have the potential to generate only small changes in employment By contrast, if the unions' bargaining power is high and the economy is far away from full employment, a decline in the markup can lead to large employment responses. We show that this result holds both in the short-run and in the long run, and both in efficient bargaining and right-to-manage frameworks. Moreover, we build on and expand the version of the Blanchard-Giavazzi model that allows unions to lobby for labor market regulations that increase their bargaining power. The idea is that, by increasing competition and downward pressures on market rents, product market deregulation also reduces incentives for unions to seek increases in their bargaining power through stricter labour market settings. This is consistent with a burgeoning political economy literature that links competition to weakening bargaining power of workers.[5]

We then test the model's predictions on harmonized panel data for OECD countries over the period 1980-2002. We approximate product market reforms with a new set of indicators that include both changes in domestic regulation and in border barriers to investment, while

[5] The idea that competition can weaken workers' bargaining power has been explored in several other recent theoretical studies. Ebell and Heafke (2006) develop a model in which greater product market competition induces a shift from collective to individual bargaining. In Boulhol (2006) trade and investment liberalization generates pressures on social partners to lift labour market regulations that enhance workers ' bargaining power (such as, restrictive employment protection legislation). Rodrik (1997) was among the first to suggest the idea that import competition can weaken workers' bargaining power.

labour market settings are described by standard indicators of policies and institutions. We also explore the determinants of product and labor market policies and institutions and we control for their endogeneity in the employment rate equation. The results confirm that market-friendly product market reforms over the past two decades have produced substantial employment gains in the OECD countries. There is also evidence that employment gains have been larger when workers' bargaining power was initially high as a result of stringent labor market regulations. In this sense, product and labor market deregulation can be classified as "economic substitutes". However, we also find evidence that product market deregulation has led, over time, to a decline in workers' bargaining power, through its effect on union density and coverage, and/or through an easing of labour market policies, summarized by a combination of employment protection and unemployment benefit regimes. In this sense, product market and labor market deregulation can be considered as "political economy complements" as reforms of the former induce reforms of the latter. Thus, in assessing the long-run employment effects of product market deregulation one needs to consider both its direct effect and the indirect effect stemming from the induced changes in labor market policies and institutions. The overall results are consistent with the predictions of our model.

The structure of the paper is as follows. In Section 2 we present the extended version of the Blanchard and Giavazzi (2003) model and discuss its main predictions. In section 3 we discuss the data. In section 4, we outline our empirical strategy, while Sections 5 presents our empirical results of the employment rate equation based on specifications that policies are exogenously and independently set. In Section 6 we discuss the determination of product and labor market regulation and address the issue of its potential endogeneity in the employment equation. Section 7 concludes the paper.

2.2 A simple bargaining model with interactions between product and labour markets

In this section we present a simple bargaining model that provides a framework for assessing the effects of product market liberalization on employment, while also considering possible interactions between product and labour market regulation. The first question the model addresses is whether, for independently- and exogenously-set policies, a deregulation of the product market has more beneficial employment effects when the labor market is heavily or lightly regulated. The second question is whether product market deregulation may actually lead to labor market deregulation. We discuss these issues in the context of the bargaining model proposed by Blanchard and Giavazzi (2003, BG thereafter), extended to allow for a richer specification of the fall back position of the union and taxation. This yields interesting predictions about the interaction between product and labor market policies both in the short and long run. We first summarize the basic set up and predictions in the context of an efficiency bargaining model (details are confined to Appendix A). In the following section we then discuss the results in the case of a right-to-manage model. Finally, we present a version of the model where workers' bargaining power is endogenous and depends on the mark-ups.

2.2.1 Efficient bargaining model

Employment and the wage are determined by solving a cooperative Nash Bargain between unions and imperfectly competitive firms. Denoting by V_i the union's utility function and by Π_i the firm's profits, the efficient bargain solution is obtained maximizing with respect to both the wage and employment the generalized Nash maximand , $\beta \ln(V_i - \overline{V_i}) + (1-\beta) \ln \Pi_i$, where β captures the union bargaining power. We will assume that β is affected by labor market policies, such as employment protection legislation and the generosity of income support systems for the unemployed that reduce the pressure of outsiders on incumbent workers. It can also be affected by institutional characteristics of the labor market such as union density (the proportion of workers who are union members) and coverage rate (the share of workers covered by bargaining agreements). V_i is equal to the sum of the income of employed workers, L_i,who earn a wage equal to $\frac{W_i}{P}$ and the income of union members not employed by the firm, whose expected income is $\frac{W_i^A}{P}$. $\overline{V_i}$ represents total income expected by the union if a bargaining agreement is not struck with the firm and equals $\frac{W_i^A}{P}$ times union membership, N. In defining $\frac{W_i^A}{P}$ we will assume that the alternatives to employment with the present firm are either unemployment benefits, public employment, or a job with another firm. Unemployment benefits are not taxed and public employment is assumed to be fixed exogenously. For simplicity we assume that the private and public wage are identical. Firm i uses one unit of labor, L_i, to produce one unit of output, Y_i. Each firm faces a downward sloping demand function with elasticity $\sigma = \overline{\sigma} g(m)$, with $g' > 0$. σ captures the elasticity of substitution among goods, $\overline{\sigma}$ is a constant, and m denotes the number of firms. The markup over marginal costs, μ, equals $\frac{1}{1+\sigma}$.We will assume that the markup is affected by product market policies, such as legal constraints to entry or to rivalry among firms. Labor income is subject to an income tax rate of τ^L, while employers are subject to a payroll tax of τ^p. Finally, to close the model, we will assume that the government budget is kept in balance (and there is no public spending on goods).

In the efficient bargain, at an optimum, relative output prices, $\frac{P_i}{P}$, and the real wage, $\frac{W_i}{P}$, are proportional to the alternative wage, with constants of proportionality equal to $(1+\mu)(1+\tau^p)$ and $(1+\mu\beta)$ respectively. In the symmetric short run equilibrium ($\frac{P_i}{P}=1$, $\frac{W_i}{P}=\frac{W^o}{P}=\frac{W}{P}$, fixed number of firms), the alternative wage and the real wage are:

$$\frac{W^A}{P}=\frac{1}{(1+\mu)(1+\tau^p)} \tag{2.1}$$

$$\frac{W}{P}=\frac{(1+\mu\beta)}{(1+\mu)(1+\tau^p)} \tag{2.2}$$

Using the definition of the alternative wage, the assumption that private and government wages are equal, and the balanced budget condition, we can obtain an upward sloping relationship between the alternative wage and the employment rate:

$$\frac{W^A}{P}=\frac{(1+\mu\beta)}{(1+\mu)(1-\tau^l)}l \tag{2.3}$$

where $l=\frac{L}{N}$ is the employment rate. Its short run equilibrium value is obtained by solving (2.1) and (2.3):

$$l=\frac{1}{(1+\mu\beta)\frac{(1+\tau^p)}{(1-\tau^L)}} \tag{2.4}$$

Note that, given public employment and the equilibrium values of private employment and of the wage, the balanced budget condition determines unemployment benefits. Moreover, using the balanced budget condition one can eliminate public employment and unemployment benefits from the solution.

Contrary to BG, employment depends on β also in the short run equilibrium due to the fuller specification of the fallback position of the union. This result holds even if we do not make use of the balanced budget condition. As a result, a decrease in the union bargaining power leads to an increase in employment. As in BG, a decrease in the markup, due, for instance, to an increase of substitutability between products, captured by an increase in $\overline{\sigma}$, or to an exogenous increase in the number of firms also leads to an increase in employment. The increased substitutability could be for instance the result of measures that decrease border barriers, thereby facilitating the entry of foreign products into the domestic market. An increase in the number of firms, may be due to a policy-induced decrease in entry barriers, which will be analyzed more fully below. Finally, employment will be adversely affected by payroll or income taxes.

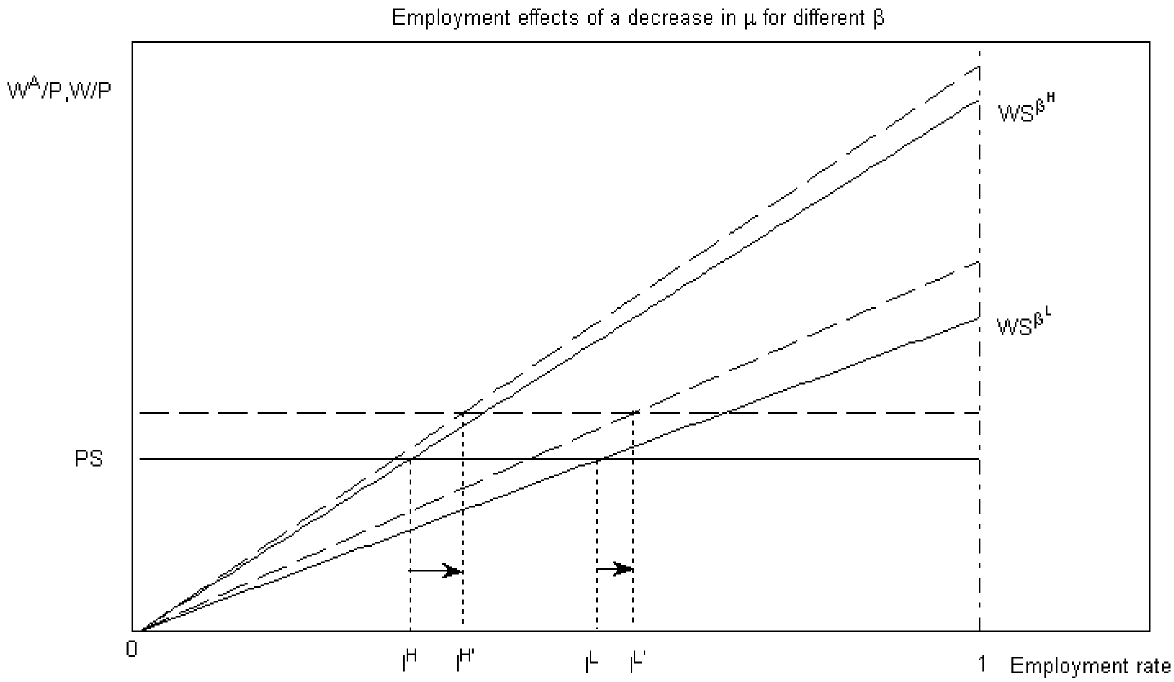
What is of particular interest for us here is the interaction between product and labor market regulation, captured by μ and β, respectively, assuming for the time being that they are set independently from one another. It is easy to see that the cross derivative of employment with respect to μ and β is negative in our model. This implies that, at the margin, a reduction in the markup has greater positive effects on employment when the labor market is more regulated and unions have greater bargaining power. Some authors define product and labor market deregulation as substitutes in this case. When the cross derivative is positive and it pays more in terms of employment to reduce the markup when the union bargaining power is low, then product and labor market deregulation are classified as complements.[6]

We can give a graphical presentation of this general equilibrium result by plotting equation (2.1) and (2.3) in a graph with the employment rate on the horizontal axis and the alternative wage on the vertical axis. In Figure 1 (2.1) is denoted by PS and (2.3) by WS^{β^H} when drawn for a high value of β and by WS^{β^L} for a low value of β.[7] The relationship between the alternative wage and employment is steeper when β is high.

Figure 1

[6] In Blanchard and Giavazzi (2003) the effect of product market deregulation is independent of labor market regulation in the short run, since employment in the efficient bargain does not depend upon the bargaining power parameter, β. This is mostly a consequence of the assumption that the fall back position of the union only depends upon the unemployment rate and is independent of the wage, in equilibrium.

[7] Note that PS and WS are general equilibrium loci. For instance PS identifies the level of the alternative wage compatible with $\frac{P_i}{P} = 1$ in the symmetric equilibrium. One could also draw in the graph the marginal revenue product schedule for an individual firm, which would shift with changes in μ, buth this would clutter the figure.



A decrease in μ, due, for instance, to product market deregulation that increases the substitutability among goods (reflected in an increase in $\overline{\sigma}$), shifts PS upward by the same amount, whatever the value of β. Moreover it makes the relationship between the alternative wage and employment, WS, steeper. The first effect dominates, generating always an increase in employment. However, following the decrease in μ , the increase in the slope of WS^{β^H} is smaller than the one for WS^{β^L}. As a result, there is a larger positive employment response when unions' bargaining power is high: employment increases from l^H to $l^{H'}$when β is high, and from l^L to $l^{L'}$when β is low. [8]

[8] For given l the increase in $\frac{W^A}{P}$ following an infinitesimal decrease in μ equals $\frac{1-\beta}{(1+\mu)^2(1+\tau^L)}l$.
Note that both the numerator of the fraction and l are smaller when β is higher. The relative size of the

The basic intuition behind this result is that low unions' bargaining power will be associated with low real wages and employment close to the full employment level. In this case product market deregulation measures that lead to a decrease in the markup have the potential to generate only small changes in employment. If the unions' bargaining power is high and the economy is far away from full employment, a reduction in the markup can lead, instead, to large employment responses. This intuition holds, not only when the economy literally hits the full employment constraint, but also when it is below full employment. To see this, consider that when β is close to one, workers are already extracting most of the rents and it is not possible for decreases in μ to be associated with further wage increases (when $\beta = 1$ the wage will be actually independent of μ). This explains why the upward rotation of the WS locus is smaller when β is high and why, as a result, the decrease in the markup generates a greater increase in employment.

Note, instead, that in this model the cross derivatives between μ and taxes, or between β and taxes, are positive. This means that the positive employment effects of deregulating the product or labor market are greater when taxes are low.

The qualitative results concerning the effect of product and labor market deregulation and their interaction also hold in the long run. In long run steady state equilibrium the number of firms in the markets and hence the markup will be determined by the condition that profits, (A1), must be equal to (annualized) entry costs, c, assumed to be a fraction of output. Using this condition together with the equations defining the optimal value of

rotation for different values of β is crucial in generating the result that product and labor market deregulation are "substitutes". This is what matters, not the fact that (2.3) is flatter for low levels of β. This may give the mistaken impression that a decrease in μ generates a greater employment response when β is low. This would be true if only PS shifted upward. However, the decrease in μ also makes WS steeper, and by less when β is greater.

employment and the real wage, (2.2)and (2.4), the long-run equilibrium levels of employment and wages are:[9]

$$l = \frac{(1-\beta-c)\left(1-\tau^{L}\right)}{(1-\beta-c+c\beta)\,(1+\tau^{p})} \tag{2.5}$$

$$\frac{W}{P} = \frac{(1-c)}{(1+\tau^{p})} \tag{2.6}$$

A decrease of entry costs, c, union power, β,or taxes will all have a positive employment effect. The cross derivative with respect to β and c is negative, provided $\beta < \frac{1}{\mu}$ which is the case for any realistic value of μ. This implies that a reduction in entry barriers is more effective in highly regulated labor markets where union power is high. As in the short run, the interaction between taxes and c or β is positive.

2.2.2 Right to Manage model

The results we have obtained so far concerning first and cross derivatives are fundamentally robust to assuming that firms and unions bargain only about the wage and firms are allowed to hire along their labor demand function (the Right to Manage model). In this case, profit maximization implies that prices will be set by the firm as a markup above the real wage, adjusted for payroll taxes so that $\frac{P_i}{P} = (1+\mu)\,(1+\tau^{p})\frac{W_i}{P}$.In the symmetric short run equilibrium, the wage will be:

$$\frac{W}{P} = \frac{1}{(1+\mu)\,(1+\tau^{p})} \tag{2.7}$$

This equation can be thought of as the aggregate price setting equation. Using the first order condition for the wage, together with the definition of the alternative wage and the

[9] The equation defining the markup is $\mu = \frac{c}{1-\beta-c}$, so that μ is increasing in c and β.

balanced budget condition, one can obtain the following relationship between the real wage and the employment rate:

$$\frac{W}{P} = \frac{(1+\mu\beta)}{(1+\mu)(1-\tau^l)} l \tag{2.8}$$

This equation can be interpreted as the aggregate wage setting locus. Note that the aggregate price setting and wage setting equations, (2.7) and (2.8), in the Right to Manage model are identical to the corresponding equations in the Efficient Bargain model, (2.1) and (2.3), the only difference being that the actual wage has now replaced the alternative wage in the expressions. As a result the short run solution for employment in the Right to Manage model is identical to the one in the Efficient Bargain model (see (2.4)) and all the conclusions reached before about first and cross derivatives still hold. In particular the effect of a decrease in the markup is greater when unions have greater bargaining power.[10] Note also that the graphical presentation of the model in Figure 1 and 2 remains valid by simply relabelling the vertical axis to represent the real wage and not the alternative wage. In this case the horizontal line, PS, is the aggregate price setting locus, while the upward sloping one is the aggregate wage setting locus, WS. When the markup decreases, PS shifts upward by the same amount, while WS becomes steeper, but by a lesser degree when β is high. In other terms, the wage becomes less sensitive to changes in employment along the aggregate wage setting function, but to a lesser degree when unions are more powerful. Again, the intuition is that there is little room to extract higher wages, following a decrease in μ, when the unions are already appropriating most of the rents. This is reflected in a

[10] In a related paper, Griffith et al. (2007) show that a decrease in the markup will increase employment more in a model with a monopoly union, compared with a model with a competitive labor market. On a related topic, see Kugler and Pica (2004) for a matching model with entry and dismissal costs (tested on micro data) that implies that stricter entry regulation reduces the effectiveness of labor market reforms in generating new jobs.

smaller increase in the slope of the wage setting locus and, therefore, the decrease in the markup will result in a larger increase in employment.

In the long run, however, the employment solution for the Efficient Bargain and for the Right to Manage model differ from one another. More precisely, when the number of firms is endogenized by equating monopoly profits to entry costs, long run employment and wages are[11] :

$$l = \frac{(1+\tau^p)}{(1-\tau^L)} \frac{1-c}{1-c+c\beta} \tag{2.9}$$

$$\frac{W}{P} = \frac{1-c}{1+\tau^p} \tag{2.10}$$

The first derivatives of employment with respect to β and c and taxes are negative as before, and so is the cross derivative between β and c. Therefore, also for the Right to Manage model the effect of reducing entry barriers on employment is greater when labor market policies or institutions lead to a high bargaining power for the unions.

2.2.3 Endogenizing union's bargaining power

We now ask the question whether product market deregulation may lead to labor market deregulation. Blanchard and Giavazzi (2003) endogenize β by assuming that it is the solution to the *union's* problem of maximizing the labor income share (equal to the wage in the model), net of lobbying costs, that are assumed to be quadratic in β. They show that product market deregulation that results in a lower mark-up will lead to a decrease in union' bargaining power in the short run. We modify their set up by assuming that the objective

[11] The expression for the markup is now $\mu = \frac{c}{1-c}$.

function of the lobby (union confederation, political party) representing the unions in the first stage of the game is the union utility in excess of the fall back position, minus quadratic lobbying costs. This is more consistent with the union utility function used in the Nash bargaining stage of the game. Moreover, we analyze the effect of product market regulation on workers' bargaining power both in the short run and in the long run. We assume that the lobby knows that employment and wages are determined by the efficient solution to such Nash bargain (or to the Right to Manage model), and their resulting equilibrium values.[12] The optimal value of β is a solution to:

$$\underset{\beta}{Max}\left[\left(1-\tau^{L}\right)\left(\frac{W_i}{P}-\frac{W_i^A}{P}\right)L_i-\frac{a}{2}\beta^2\right] \tag{2.11}$$

Using the short run equilibrium wages and employment for the efficient bargain, equations (2.2) and (2.4) in (2.11), one can show that $V_i-\overline{V_i}$ is increasing in both β and μ.[13] Most importantly for us, a decrease in μ will generate a decrease in β. The sign of the effect depends upon the cross derivative of $V_i-\overline{V_i}$ with respect to μ and β. This cross derivative is positive in our model and this implies that the losses from a decrease in β are smaller when markups, and hence the monopoly profits to be shared between firms and workers, are low. This reduces the incentive to lobby or fight for a high β and explains why lower product market regulation (and the associated lower μ) leads to lower labor market

[12] One can think that a portion of lobbying costs are split equally among the various unions, but they will not affect the solutions derived so far for wages and employment as they disappear from the Nash maximand, since they are subtracted from both the union utility and from its disagreement level (both assumed to be linear in income). A fraction of lobbying cost falls directly on the lobbying organization itself (that we do not model fully). See Rama and Tabellini (1998) for a fuller analysis of lobbying for trade protection and labor market policies.

[13] The fact that union utility above the fall back position decreases when the markup decreases may explain by itself why unions may not be supportive in practice of product market reform, independently of possible effects of μ on β.

regulation. These results carry through to the long run , in the sense that lower entry costs lead to lower bargaining power for the unions, but only if the union is not too powerful to start with. More precisely, β is decreasing in c if $\beta < \frac{1-2c+c^2}{1+2c-c^2}$. They also tend to extend to the Right to Manage model in the short run for realistic values of μ (or c) and β.[14] Ultimately, whether product market deregulation induces or not labour market deregulation is an empirical issue.

2.3 Data

The empirical analysis is based on harmonized annual data for a sample of 20 OECD countries over the period 1980-2002.[15] We relate the employment rate (the share of the working age population in employment) to labour and product market regulations and policies that are likely to affect firms' market power (the markup in our model) and workers' bargaining power. In addition, we control for the business cycle and other unobservable time invariant country specific effects, as well as for country specific trends and common year effects. The description of the key variables is provided below. Further details on data sources and definitions are provided in Appendix B.

[14] More precisely, the condition for β to be increasing in μ in the short run is:

$$1 + \beta^2\mu^2(1 + 2\mu) > 4\beta\mu(1 + \mu)$$

In the long run β is increasing in c if:

$$1 + 4\beta c^2 > 4c^2 + 2\beta c + c$$

Remember that c is expressed as a share of output. If, in the first stage the union lobby maximizes the wage per worker (equal to the labor share of income) as in Blanchard and Giavazzi (2003), there is a positive association between μ (c) and β only for the efficient bargain in the short run. In all other cases there is no effect of product market deregulation on unions' bargaining power.

[15] The countries are Australia, Austria, Belgium, Denmark, Germany, Greece, Finland, France, Italy, Japan, Ireland, the Netherlands, New Zealand, Norway, Portugal, Spain, Sweden, Switzerland, the United Kingdom and the United States.

Employment Rates. The dependent variable in our equations is the non-agricultural employment rate, ERB, the component of employment most directly influenced by labour and product market policies and institutions. [16]

Product market regulation. We use time-series data on product market policies that restrict competition to measure market liberalization in the OECD countries covered by the analysis. The data cover both domestic regulations and border barriers. For domestic regulations we draw on Conway and Nicoletti (2006) who provide indicators over the 1975-2003 period for the following non-manufacturing industries: gas, electricity, post, telecommunications, air transport, rail transport and road freight. [17] Their indicators cover three main areas: public ownership of business sector firms, legal barriers restricting access to markets and other barriers to entry related to market or industry structure (e.g. market dominance and vertical integration in network industries). [18] Indicators for each of these areas are based on detailed information on laws, rules and market and industry settings. In each period and each area, country-industry observations are scored along a cardinal scale from least to most restrictive. Area-wide indicators (e.g. for public ownership or legal barriers) are subsequently obtained by averaging these scores across industries and an overall indicator of regulation in energy, transport and communication is obtained by averaging across both areas and industries. To account for the effects on employment of dif-

[16] We separately control for the share of public employees in the working-age population (the public employment rate – ERG) to test for the hypothesis that the latter may crowd out business sector employment opportunities. In preliminary analysis, we experimented with both total non-agricultural and business non-agricultural employment rates. Here we focus on the unrestricted version of the model in which the effect of public employment is estimated. A significantly negative coefficient on the public employment variable would support the crowding out hypothesis.

[17] Nicoletti and Scarpetta (2003) and Alesina et al. (2005) used an earlier version of these indicators to estimate the effects of anticompetitive regulation on productivity and investment, respectively.

[18] The coverage of these three areas varies across industries. Legal barriers are reported in all industries; public ownership is covered in all industries except road freight; vertical integration is documented for gas, electricity and railways; market structure is reported for gas, telecoms and railways.

ferent areas of regulation, in our regressions we experiment with three area-wide indicators: one excluding public ownership, REG, a second one focusing more narrowly on barriers to entry and vertical integration, $REGbevi$,and finally one covering only public ownership, $REGpo$. All indicators suggest substantial cross country differences in the average level of regulation and a trend towards deregulation in the later years that differs in timing and intensity across countries. In figure B1 we report, as an example, the cross country and time series variation for REG. We supplement this information on domestic regulations with the indicator of FDI restrictions provided by Golub (2003) and Golub and Koyama (2006). This indicator covers limitations on foreign ownership, restrictive screening and notification procedures and operational restrictions for foreign affiliates in the manufacturing sector and eight non-manufacturing industries over the 1980-2006 period. The construction of this indicator follows the same steps as for the indicator of domestic regulation: the basic information is scored from least to most restrictive in each period and area-wide indicators are derived for each industry and across industries; finally an aggregate indicator for the whole economy is obtained by averaging. [19] To account for both domestic and border barriers to competition, in the empirical analysis we also use a summary indicator, $REGfdi$, obtained as the first principal component of REG and of the aggregate indicator of FDI restrictions (both standardized). The resulting indicator is reported in Figure B2. Note that the first principal component of two standardized variables gives equal weight to each one of them and, hence, is proportional to their arithmetic average. It should be noted that, even though barriers to foreign investment in the manufacturing sector are covered,

[19] The aggregate indicator of FDI is an average of the indicators for the various industries weighted by a combination of industry shares in trade and FDI flows (see Golub (2003)).

our measures of restrictive product market policies focus mostly on the non-manufacturing industries, where restrictions are covered in more detail. Unfortunately, little time-series information is currently available on restrictions affecting the manufacturing industries.[20] This may not necessarily be a serious empirical problem, however. In the OECD countries covered by our regressions, the non-manufacturing industries account for a large and increasing share of aggregate employment. Moreover, anti-competitive regulations are usually concentrated in these sectors. Finally, deregulation in these sectors can have important consequences for the structure of costs in manufacturing, given the input-output linkages.

Employment protection legislation and unemployment benefits. To gauge the effects of labour market policy and institutional settings on workers' bargaining power we focus on employment protection and the generosity of the unemployment benefit system. These policies can increase the power of "insiders". In particular, EPL tends to raise labour adjustment costs, thereby making it harder for employers to adapt the workforce to the evolution of demand. The unemployment benefit replacement rate affects the cost of being unemployed and, therefore, the workers' fallback position. In particular, while, on the one hand, income support for the unemployed can facilitate job search and improve job matching, on the on the other hand, it raises the reservation wage and it is likely to increase the bargaining power of incumbent workers. As argued below, these policies have often been seen as substitutes, with stronger employment protection partially compensating for weak income support for job-seekers, and vice versa. Hence, one way to capture labour market

[20] Detailed information on economy-wide regulations is provided by Conway et al. (2006) only for the 1998 and 2003 periods. Some authors (e.g. Griffith et al.(2006)) have used information on economy-wide domestic and border regulations provided by Gwartney and Lawson (2006) for the 1975-2003 period. However, their data are based on less detailed and more heterogeneous information than that provided in our sources and are only complete (on a quinquennial basis) from the beginning of the 1990s.

overall protection/stringency is to consider the particular combination of the two policies adopted by each country, summarizing them into a single indicator. This is the choice we adopt in our basic specification.

The indicator of EPL covers restrictions concerning workers on both permanent and temporary contracts. This information was collected and coded for the late 1980s, the late 1990s and 2003 by OECD (2004), which also provides details on sources and methodologies. Individual dismissal protections for workers with permanent contracts include: procedural inconveniences that employers face when trying to dismiss a worker; notice and severance payments at different job tenures; and prevailing standards of and penalties for "unfair" dismissals. The indicator for temporary contracts covers, for both fixed-term contracts and contracts through temporary work agencies: the "objective" reasons under which they could be offered; the maximum number of successive renewals; and the maximum cumulated duration of the contract. The EPL indicator used in the econometric analysis below is time varying, with the shifts in regime from the late 1980s to the early 2000s being defined on the basis of information about the timing of major EPL reforms (concerning both temporary and regular workers) in OECD countries. Unemployment benefit replacement rates. To capture the effect of unemployment benefits on employment, we use gross replacement rates, BEN, which are a summary measure of the fraction of income replaced by unemployment benefits over a five years period for three family types and two earnings levels. [21] We combine EPL and BEN into a single measure of labour market regulation, $LMRP$, by taking their first principal component (see Figure B3). Again recall that the first principal component is

[21] The net replacement rate would be a preferable indicator, but unfortunately it is currently available only for a few years. For a discussion of the different definitions of replacement rates, see Martin (1996).

proportional to the simple average of the two variables. The comparison between the time-series profiles of $LMRP$ and REG (or $REGfdi$) highlights that, over the sample period, product market liberalization has been more extensive and generalized than liberalization in labour markets.

Taxes on labour use. We use two measures of the tax wedge that is expressed as the ratio of total taxes and social security contributions to total labour costs (wage plus employers' social security contributions). The first measure, $WEDGE1$, is based on revenue data from National Accounts and includes, in addition to income taxes and employer's and employee's social security contributions also indirect taxes. The second indicator, $WEDGE2$, is calculated using a tax model and considers the social security contributions and taxes and benefits of an average worker with two different family situations (single and married with a dependent spouse and two children).

Unions' power and bargaining regimes. There are different indicators available to capture unions' power in the bargaining process. First, union density, the proportion of workers who are members of the unions. This variable provides a *prima facie* indication of the strength of unions. However, in countries where there is administrative extension of collective agreements (e.g. many Continental EU countries) it is a poor proxy for bargaining power insofar as even unions with low membership can exert a strong influence on wage settings. The second indicator is the share of workers covered by these agreements. Available data on coverage are too limited to be used as a separate variable in the empirical analysis (OECD (2004)). However, we tried to account for both these dimensions of union power by constructing a variable that combines union density and coverage, $UDCO$, by means of principal components analysis (see Figure B4).We think this is a better choice than union density alone, which may be a partial proxy for the bargaining power of the unions. For example union density in France is 11%, the same as in the United States, but coverage is much higher in France (around 80%).

Consistent with an extensive literature (e.g. Bruno and Sachs (1985); Calmfors and Driffil (1988); Elmeskov et al.(1998); Nickell and Layard (1998)), we also consider the wage bargaining regime. Indeed, it has been argued that both decentralized and centralized systems are preferable to intermediate ones based on bargaining at the industry level (OECD (1997); Flanagan (1998)). To account for these features, we consider both the level of bargaining, which can be centralized, intermediate (at the industry or regional level), or decentralized (at the firm level) and the degree of coordination among, on the one hand, employers' associations and, on the other hand, trade unions. Combining these two features into a low-corporatism, $LLCORP$, intermediate corporatism, $MDCORP$, and high corporatism, $HGCORP$, variable makes it possible to consider cases where cooperation between employers and unions in an industry-level bargaining system (e.g., Germany and Austria and, more recently, Italy, Ireland and the Netherlands) may be a functionally-equivalent alternative to centralized systems. This is because strong coordination allows industry unions to internalize the aggregate effects of their wage decisions into the negotiation process, *de facto* mimicking the outcomes of a highly centralized bargaining regime.

2.4 Econometric Strategy

The model described in the previous section has three main predictions. First, product and labour market regulation, by curbing competition among firms and strengthening workers' bargaining power have a negative effect on equilibrium employment. Second, reforms in these markets are economic substitutes, in the sense that product market deregulation has a larger effect on employment when the labor market is highly regulated. However, if product market competition is allowed to influence workers' bargaining power (through its effects on labor market policies or institutions), regulations in the two markets can be seen as political-economy complements as product market deregulation can lead to labor market deregulation. In this section we discuss whether the econometric evidence supports these main predictions of the model.

To better relate our results to previous literature in this area, we proceed in steps. First, we estimate the employment effects of product and labour market interactions under the usual assumption that product and labor market policies are exogenously and independently set. We then explore the determinants of product and labor market regulations and tackle head on the potentially important issue of their endogeneity in the employment equation, using a control function approach. While important for ensuring the validity of the empirical results, endogeneity issues are generally not dealt with in the empirical literature on the impact of product an labor market deregulation – and their interactions – on employment, although the endogeneity of unionization in unemployment equations has been addressed in Checchi and Nunziata (2006).

Throughout, our estimates are based on a dynamic model for the business (non agricultural) employment rate for a panel of OECD countries over the period 1980-2002. The model is estimated by feasible GLS, allowing for the variance to differ across countries and for an AR(1) structure in the error term with country-specific autocorrelation coefficients,

ρ_i.[22] Test results reject at the 1% level the equality of variance across countries and the absence of serial correlation in all specifications. We use a specification that includes lagged employment, since it is likely that the short run and long run effects of regulation differ.

Most of the previous empirical work on the interaction between product and labor market regulation has typically relied on static model specifications for employment (unemployment).[23] In principle, static regressions may be thought to capture a cointegrating relationship between the employment (unemployment) rate and the explanatory variables. However, this interpretation is questionable in our context. For instance, using the Levin, Lin, and Chu (2002) test for unit roots in panels, we can reject the unit root hypothesis for the business employment rate at the 5% level.[24] Moreover, many of the variables representing product and labor market regulation are unlikely to be well described by unit roots. These variables often display regime changes and could be erroneously interpreted as unit root processes.

All regressions include country dummies, DC_i, year dummies, DT_t, and country-specific time trends $Trend_{i,t}$. The country specific trends capture country level low frequency movements in the structure of the labour force, such as changes in participation or demographics. Moreover, they capture, potentially non neutral, technological progress, since the industrial composition varies across countries and the rate of technological progress is likely to be industry specific. As explained below, omission of these country-specific time trends may lead to misleading conclusions concerning sign of the interaction effects. We also consider

[22] The results with a common first order serial correlation coefficients are similar.

[23] Nickell et al. (2005) estimate dynamic unemployment models by feasible GLS, but do not address the issue of the interaction between product and labor market regulation.

[24] This is true in specifications with or without trends, including either two or three lags of ERB.

two additional country dummies for Germany post-reunification (1991-2002) and for Finland after the collapse of the Soviet Union (1991-2002). The main conclusions, however, do not hinge on the inclusion of these dummies. We focus on the employment rate in the non agricultural business sector in country i in year t, $ERB_{i,t}$ as the dependent variable, and estimates variants of the following equation:

$$\begin{aligned} ERB_{i,t} &= \alpha ERB_{i,t-1} + \beta PMR_{i,t} + \gamma LMR_{i,t} + \delta PMR_{i,t} LMR_{i,t} + \theta ERB_{i,t-1} LMR_{i,t} \\ &\quad \sum_{k=1}^{K} \phi_k Z_{k,i,t} + DC_i + DT_t + \psi_i Trend_{i,t} + \epsilon_{i,t} \\ \epsilon_{i,t} &= \rho_i \epsilon_{i,t-1} + \xi_{i,t} \end{aligned} \tag{22}$$

PMR denotes various measure$s$ of product market regulation, LMR various measures of labor market regulation and $Z_{k,i,t}$ a set of control variables. The focus of the paper is in assessing the sign and significance of the coefficient of the interaction between product and labor market regulation, δ. Note that we also allow the degree of persistence to depend upon labor market regulation to capture the idea that more rigidly regulated labor markets may lead to greater persistence in the employment process.

In our basic specification we report results using two measures of product market regulation: one that measures domestic restrictions to competition, REG,and another that also includes the restrictions on foreign direct investment, $REGfdi$.[25] We always include also a measure of public ownership of business enterprises, $REGpo$, as an additional regressor. As

[25] The results obtained using *REGbevi* (that focuses more narrowly on barriers to entry and vertical integration) are very similar to those obtained using *REG* and are not reported here. See the working paper version of the model for further details.

a measure of labour market regulation and policy we use the first principal component of employment protection EPL and unemployment benefits replacement rate, BEN, denoted by $LMRP$. We also report results using EPL and BEN as separate regressors. With a balanced budget, the effect of benefits on the fall back position should be captured by the tax rate. In reality, however, government budgets are often not balanced in all countries and the generosity of the unemployment benefit system also affects the bargaining power of insiders.

To account for labor market institutions, we use the principal component of union density and union bargaining coverage, $UDCO$. In the same vein, we include an indicator of corporatism – discretized in low, medium and high ($LLCORP, MDCORP$ and $HGCORP$)– which has been often used in the literature as a proxy for the degree of bargaining centralization and coordination.

In all regressions we control for business cycle fluctuations captured by the deviation of actual output from potential output, GAP. The set of control variables include taxation on labor income captured by the two different measures of the tax wedge described above, based either on tax revenue data, $WEDGE1$, or on the taxes paid by a representative worker, $WEDGE2$. The first measure better captures the average tax burden on labour use but is likely to be more susceptible to endogeneity problems due, among other things, to the progressivity of the tax system that may induce a spurious positive correlation between shocks to employment and the tax wedge, even controlling for the output gap. To tackle at least partially the endogeneity problem, we use its lagged value in the empirical analysis. The tax wedge drawn from the tax model is less subject to endogeneity problems, but refers to a representative worker and does not consider possible changes in tax enforcement and special treatments. We will address the issue of the potential endogeneity of $WEDGE2$ in section 5. We also include in the regression public employment and control for its likely endogeneity by using a lagged moving average of it at t_{-1} and t_{-2}, $ERGM$. Public employment may crowd out business employment to the extent that it improves the fall back position for the union. A negative effect on private employment may also reflect the fact that public employment produces services that are close substitute for private activities and, as well, because it has to be financed by taxation. However, public employment may increase the productivity of private employment, with favorable consequences for the latter.

2.5 Empirical Evidence on Policy Interactions: Exogenous Policies

We focus first on results obtained under the assumption that product and labour market policies are set exogenously (and independently). Estimation results obtained by using Feasible GLS are reported in Table 1. The direct effects of product market regulation, represented by REG or $REGfdi$,and of the summary measure of labor market regulation, $LMRP$, are always negative and significant in most cases at the 1% level (see columns 1 through 4).[26] Thus, high levels of regulation are associated, on average,with lower employment rates. Note that the variables in the interaction term between product and labour market regulation are either mean zero or are defined as deviations from their overall sample mean, so that the coefficient of the main effects capture the marginal effect of a variable eval-

[26] Omitting the interaction terms does not change the sign and significance of these direct effects. For more details see the original IZA or BC working paper version of this paper.

uated at the sample mean. It is also worth noting at the outset that the lagged employment variable is always highly significant, with a coefficient of around .65, pointing to a strong persistence of employment over time. Moreover, consistent with earlier results (Scarpetta, 1996; Nickell et al. 2005) the persistence significantly increases with the stringency of labor market regulation. Finally, the output gap is a very important explanatory variable in all specifications, pointing to strong cyclical effects as well.

Given the focus of this paper, the main result is that the coefficient of the interaction between our two proxies for product market regulation, REG or $REGfdi$ and labor market regulation, as proxied by the summary index $LMRP$, is negative and significant at the 5% and 1% level, respectively. Hence, consistently with the predictions of our model, deregulating the product market is more effective at the margin when the labour market is highly regulated. In this sense, product and labour market deregulation can be seen as economic substitutes. This is an important result because it suggests that in situations where labor market regulation is stringent and difficult to reform politically, deregulating the product market may be the best way to promote higher employment at the margin.[27]

The difference in the estimated effect of product market deregulation in countries where labour market policies are tight or loose is sizeable. Consider, for example, a product market deregulation that, ceteris paribus, moves a country from the third quartile (5.25) of REG to the first quartile (3.08). When labour market regulation is low and equal to the first

[27] Note that the result on the sign and significance of the interaction term is robust to using the employment rate for prime age men and women (25-54) as the dependent variable. In this case available data do not allow to distinguish between private and public employment. For instance, in the specification of Column 1 of Table 1, the coefficient of the interaction between REG and $LMRP$ is negative and significant at the 5% level and very similar in size (-.162 versus -.159). The results are also robust to controlling or not for total public employment (the coefficient on the interaction is -.162 without and -.152 with public employment). The detailed results are not reported here for reason of space, but are available from the authors upon request.

quartile of $LMRP$ (-.89), the increase in the employment rate is not statistically significant at the 5% level and equals only .18 percentage points on impact and .45 percentage points in the long run (using the results in column 1 of Table 1). When labour market regulation is high and equal to the third quartile of $LMRP$ (.95), the effect of deregulation is larger, quite substantial and significant at the 1% level. It generates an employment gain of .82 percentage points on impact and 2.82 percentage points in the long run. Another way to highlight the different effect of product market deregulation in different labour market settings is to consider that one standard deviation decrease in REG generates a long run gain in the employment rate of 1.20 percentage points in France (a high $LMRP$ country) and of only .23 percentage points in Ireland (a low LMRP country).

The coefficient of our measure of public ownership *REGpo* is generally positive but its significance varies across specifications. State owned firms may constitute a barrier to entry or a hindrance to competition for other firms (see e.g. Sappington and Sidak, 2003), but at the same time they are likely to be characterized by over-manning. The latter effect seems to be stronger, leading to a positive coefficient that is sometimes significant at conventional levels.[28] When the interaction between *REGpo* and labor market regulation is included as an additional regressor, its coefficient is never significant. The positive effect of *REGpo* on employment explains why when we use as a summary measure of regulation the simple average of *REGpo* and REG,its coefficient remains negative, but is now smaller and less significant (-0.142 with a t of -1.58 for the model of column 1, versus -.228 with a t of 2.68.when REG is used). In any case the coefficient of the interaction term remains

[28] See Azmat et al. (2007) for an analysis of the effect of privatization on the labour share in network industries.

negative and significant at the 5% level.[29]

Let us consider now the role of the additional control variables The evidence in favor of the tax wedge being an important determinant of the employment rate in this specification is mixed: the coefficient of the lagged value of $WEDGE1$ is negative and highly significant, while the coefficient of $WEDGE2$ is always insignificant.[30] The theoretical model discussed earlier in this paper also suggests that there should be interactions between the tax rate and measures of market and bargaining power. However, interactions between the two different measures of the tax wedge and REG (or $REGfdi$) and $LMRP$ were found to be (almost always) individually or jointly insignificant. The only exception is the interaction between $LMRP$ and lagged $WEDGE1$ that is positive and significant at the 5% level.[31] Thus, the model predictions concerning taxation receives no or weak support, at best, in the data.

Focusing on the effect of labor market institutions, the impact of our summary measure of union strength, $UDCO$, on the employment rate is consistently negative and significant across specifications. As for corporatism, Calmfors and Driffil (1988) suggested that it is likely to have a non-linear effect. In our analysis, we find no evidence of significant differences across bargaining systems that differ in the degree of centralization and coordination. Finally, concerning public employment, the results suggest that an increase in EGRM has

[29] Detailed results are not reported here, but are available from the authors.

[30] If we use the contemporaneous value of $WEDGE1$, its coefficient is significant at conventional levels when using $REGfdi$, but not when using REG. When we use the lagged value of $WEDGE2$ its coefficient is always not significant.

Nickell et al. (2005) find evidence of a positive effect of the tax wedge on unemployment in the context of a dynamic model. Their estimates, obtained using a definition of the tax wedge based on tax receipts from national accounts data, exploit a longer time series (1961-1995) that covers wider fluctuations in the taxation of labour. Moreover, Elmeskov et al. (1998) found that the tax wedge (from the tax model) has a positive effect on unemployment in countries with intermediate bargaining regimes, where wage negotiations do not allow higher taxes to be passed through to lower take home wages.

[31] When we interact the tax wedge with the corporatism variable – to account for the possible effects of bargaining systems on the ability of firms to shift labor taxes on to wages – the coefficient of the interaction term is not significant.

a negative but *in*significant effect on business employment.

In columns 5 and 6 of Table 1, we also allow BEN and EPL to enter as independent regressors in the model that uses $WEDGE1$ and we include separate interactions between each one of them and both the lagged dependent variable and product market regulation. As expected, higher EPL increases the persistence of the employment rate.[32] EPL also has a negative and significant effect on the employment rate. The coefficient of BEN is not significant. The interaction between REG and EPL is not significant while the one with BEN is negative and significant at the 5% level. These results are confirmed when we consider $REGfdi$ as the measure of product market regulation. The results are also robust to using $WEDGE2$ as a measure of the tax wedge. The general message that product and labour market regulations are substitutes, therefore, remains, although it appears that the negative interaction between the various measures of product market regulation and $LMRP$ is mostly driven by the interaction with our measure of the unemployment benefit replacement rate.

As already mentioned, EPL and BEN represent two alternative ways to protect workers against dismissal. For example, Buti et al. (1998) suggest that protecting jobs - through EPL – may act as a substitute for protecting workers after the dismissal by supporting their job search with unemployment insurance benefits. Under this hypothesis, countries might opt for either generous unemployment benefits with lax EPL or the reverse. [33] Indeed, across the OECD area - and in particular within Europe - there is a negative relationship between the stringency of EPL and the generosity of BEN. Empirically, the trade off between

[32] We have also interacted the lagged dependent variable with BEN, but the interaction is always insignificant, and therefore it has been set equal to zero.

[33] Boeri et al., (2003) document and formalize this policy interaction in a political economy context.

these two policies has been recently documented by Neugart (2007).[34] Given this trade off, it is useful to consider them jointly in regression analysis, as we do when we use $LMRP$ as a summary measure of labor market regulation, since it may be difficult to distinguish their separate effects reliably.

We have also explored the sensitivity of our results to the exclusion of the unobserved time effects. In column 7 and 8 of Table 1 we estimate the same specification of columns 1 and 2 without country-specific trends. A number of results change when the country-specific trends are omitted. Notably, the coefficient of the interaction between product and labour market regulation now becomes positive and significant when product market regulation is proxied with $REGfdi$. When using REG, the coefficient of the interaction is also positive, but not significant. Therefore, omission of country-specific trends blurs the substitutability between product market regulation and labour market settings. Omitting these trends, as in some previous studies of policy interactions, leads to serious misspecification insofar as they capture low frequency movements in the structure of the labour force (e.g. changes in participation or demographics) and/or (potentially non neutral) technological progress. Results not reported here also show that omitting trends in a static employment model results in a positive, although not significant, coefficient of the interaction term. When they are included in the static model, we obtain a negative and significant coefficient for the interaction term between product and labor market regulation. The inclusion or not of the country specific trends is, therefore, very important in explaining the difference between our results and those in Berger and Danninger (2006) and Bassanini and Duval (2006), who

[34] The trade off appears to be particularly sharp across OECD countries when accounting for the average number of inactive household members.

find, using static models, that product market deregulation and labour market deregulation (proxied by EPL) are complements, in a specification without country specific trends.

In Table 2 we further extend the estimated model by including the interaction between product market regulation and labour market institutions. More specifically, we introduce an additional interaction between REG or $REGfdi$ and the principal component of union density and contract coverage, $UDCO$. We do this because $UDCO$ is also a very reasonable proxy for union bargaining power. Moreover, we also interact $UDCO$ with the degree of corporatism to check whether the negative effects of unions' power on employment depend on the type of bargaining system. Perhaps surprisingly, the findings show that none of these interactions are significant at the 5% level (in only one case the interaction between REG and $UDCO$ is significant and positive at the 10% level, when using $WEDGE2$). Most importantly, the conclusions reached previously concerning the interaction between labour market policies and product market regulation remain unchanged.[35]

2.5.1 Determinants of product and labour market regulation and endogeneity issues

So far we have assumed that product and labour market policies are exogenous and set independently from one another but, as discussed above, there are good political economy reasons to believe that they can indeed be interrelated. The simple model of Section 2.3, that generalizes the result in Blanchard and Giavazzi (2003), suggests that product market deregulation may lead to labour market deregulation and, as already mentioned, this linkage

[35] Griffith et al. (2007) find that, in the context of a static model, a decrease in profitability caused by product market deregulation has a more favorable effect on unemployment when union density or collective bargaining coverage is high.

has been explored in a few other theoretical settings. In this section we explore this issue and the related issue of the potential endogeneity of product and labour market regulation (and of other variables) in the employment equation.

Accounting for political economy considerations

What determines the product and labor market settings that prevail in a country at a particular time? In Table 3 we present (extended) Granger causality tests of product and labour market regulation, focusing on our summary measures of labor market policies and of union bargaining power. That is, we investigate whether our measures of product market regulation Granger cause $LMRP$ and $UDCO$ (and vice-versa), after controlling for additional macroeconomic and political economy variables.

More specifically, we regress $LMRP$ on its own two lags and two lags of REG (or $REGfdi$) and we do a parallel exercise for these summary measures of product market regulation. We then add our measure of unions' strength, $UDCO$, to the system. As in Hoj et al. (2006), we control for a number of potential political economy influences on the reform process. Given that reforms are sometimes set in motion by economic crises, we include as controls the first and the second lag of a dummy that takes value 1 if the output gap drops by more than 4% ($BIGCRISIS$). We also take into account other political economy variables: the political orientation of the government (left or right of center), captured by the dummy variable $LEFT$ that equals one if the government is left-of-center; and the length of time the government has been in power, OGOV. All the equations are estimated again by feasible GLS, allowing for a different error variance in each country. We also allow for AR(1) errors with country specific autocorrelation coefficients in all equations, except in the ones for $LMRP$, since testing suggests the presence of residual autocorrelation in all cases, except for $LMRP$.[36] All specifications include country dummies, country-specific trends and year dummies. We test whether the coefficients of the first two lags of the included variables are jointly significant and also if their sum is different from zero.

Political economy variables help explain both product and labour market regulation. Notably, crises have opposite effects on the two markets: labour regulation tends to be tightened while product markets tend to be liberalized after severe downturns. At the same time, mature governments are more likely to implement product market reforms and, not surprisingly, left-of-center governments are more willing to tighten regulations in both labour and product markets.[37]

More importantly, the results suggest that REG Granger-causes $LMRP$ (the marginal significance level of the test is reported under joint sign. REG in Table 3). The converse is not true. In addition, the sum of the coefficients on the two lags of REG is positive and significant, which means that domestic deregulation of the product market leads to lower regulation in the labour market in the long run (the marginal significance of the test reported as sign. sum REG in Table 3). By contrast we do not find evidence that $REGfdi$ Granger-causes $LMRP$. An implication of this result is that in assessing the effect of product market deregulation one should consider also its indirect effects through subsequent changes in labor market policies. Another implication is that sequencing reforms to deal first with product markets could make it easier to overcome political opposition to labour market deregulation later on. In this sense product and labor market deregulation

[36] Allowing for AR(1) errors also in the $LMRP$ equation does not alter the results.

[37] These results are broadly consistent with the findings of Hoj et al. (2006) and Duval and Elmeskov (2005).

are political economy complements.[38]

Next, we also include in the regression lags of $UDCO$ (columns 5-10). The findings in columns 1-4 are confirmed: REG Granger causes $LMRP$, but the same is not true for $REGfdi$. However, $REGfdi$ and REG Granger cause $UDCO$ (at the 1% and 10% significance level respectively): product market deregulation, especially when measured by a decrease in $REGfdi$, leads to lower unions' power. There appears to be some evidence, therefore, that deregulating the product market has a positive indirect effect on employment because it induces either lower labour market regulation or weaker unions' power.[39] Interestingly, $UDCO$ Granger causes $REGfdi$ (at the 1% significance level) , but with a negative sign: higher levels of $UDCO$ lead to less stringent product market regulations. This result is puzzling and deserves further investigation.

Allowing for the impact of product market deregulation on labour market policies (or institutions) can increases its employment effect substantially. For instance, consider the long run effect on employment of a product market deregulation that moves a country from the third quartile of REG to the first quartile. For a back of the envelope calculation of

[38] Dang, Galasso, Hoj, and Nicoletti (2006) and Checchi and Nunziata (2006) also find an empirical link between policies (or institutions) in the two markets. There is also empirical evidence that trade liberalization and market-oriented reforms in the product markets have reduced workers' bargaining power. Initial findings by Abowd and Lemieux (1993) for Canada were followed by evidence by Dumont et al. (2006) and Boulhol et al. (2006) for European countries and by Dreher and Gaston (2007) for OECD countries.

[39] In our analysis, we have considered the two components of $LMRP$ – BEN and EPL – as a policy package to provide protection to workers. If we include them separately in our causality tests, we cannot reject absence of Granger causality from REG to EPL. However, there is some evidence that REG leads to lower EPL, based on the test of equality to zero of the sum of the coefficients, in the specification that imposes equal error variance across countries. There is also evidence that REG Granger causes BEN, at the 10% significance level. The sum of the coefficients is positive and significantly different from zero at the 5% level. There is also substantial evidence that BEN and EPL Granger-causes REG. The sum of the coefficients is positive for EPL and negative for BEN. The result for EPL does not have a straightforward interpretation. The one for BEN could be taken to suggest that more generous benefits may help product market deregulation by providing a cushion to the greater turbulence in employment. See Alesina et al. (2007). These results are tentative and further investigation is needed. Finally, there is ample evidence that $REGfdi$ Granger causes $UDCO$ (at the 1% significance level).

the change in the estimated long run effect of REG on $LMRP$, focus on the equation for employment and for labor market regulation together, disregarding the feedback implied by the product market regulation equation Using the results for employment in column 1 of Table 1 and those for $LMRP$ in column 1 of Table 3, the long run increase in the employment rate goes from .45 percentage points (when the effect of product market deregulation on labour market policies is not considered) to 1.95 percentage points (when such interaction is taken into account), under the assumption that labour market regulation is low and equal to the first quartile of $LMRP$. When labour market regulation is high and equal to the third quartile of $LMRP$, the employment gain following product market deregulation increases from 2.82 to 5.74 percentage points in the long run.

Controlling for endogeneity issues in the employment equation

In this section we deal with the possible endogeneity of some of the explanatory variables, in particular of the product and labour market regulation and of the unionization-coverage variable. More specifically, if the error term in the employment equation is uncorrelated with the ones in the equations generating $LMRP$, REG, $REGfdi$, and $UDCO$, then there are no endogeneity problems coming from this source. However, if the correlation is non zero, then the estimates of the employment effects of product and labour market policies and of labour market institutions obtained by GLS are, in principle, inconsistent.

Table 4 presents the endogeneity tests and estimation results that control for the endogeneity of $LMRP$, REG, $REGfdi$, and $UDCO$. In addition, we allow for the endogeneity of the GAP variable[40] At the bottom of the columns we report the endogeneity test for

[40] The bias due to the endogeneity of GAP is unlikely to be very large since there is little correlation

the employment model of columns 1 and 2 of Table 1 (results for other specifications are qualitatively similar). The test is based on the control function approach of Rivers and Vuong (1988) and it is implemented by introducing the estimated errors from the first stage equations for $LMRP$, REG, $REGfdi$, $UDCO$ and interactions of the errors with other variables (due to the presence of interaction effects) in the employment equation.[41] We also add the residuals of an AR(2) model for the GAP variable. The test of joint significance of the terms containing the errors is a test of endogeneity of $LMRP$, REG, $REGfdi$, $UDCO$ and GAP. Moreover, in the presence of endogeneity, the estimated coefficients on the variables of interest obtained by adding the first stage errors (and the appropriate interaction among them) are consistent, although their standard errors are incorrect due to the generated regressor problem. We report such estimates in columns 1 and 2 with corrected standard errors, using an extension of the formulas in Murphy and Topel (1985). In column 3 and 4 we add $WEDGE2$ to the list of endogenous variables, modelling it as an AR(2) process as well. The tests suggest that we can reject the absence of endogeneity problems at the 5% level, but not at the 1% level (with one exception), suggesting that the GLS estimates in columns (1) and (2) of Table 1 and 2 may be inconsistent.

The instrumental variable estimates presented in Table 6, which correct for these potential biases, suggest nonetheless that the qualitative conclusions we have reached in previous sections concerning the effect of product market deregulation on employment are robust to accounting for endogeneity. More specifically, the coefficient on the main effect of labor mar-

between GAP and REG, $REGfdi$, $LMRP$, and $UDCO$ (the correlation coefficients are respectively -.10, .03, -.07).

[41] More specifically, we add to the employment equation the estimated innovation in the $LMRP$, REG, $REGfdi$, and $UDCO$ equations, denoted respectively by u^L, u^P, u^U, as well as $u^L * u^P, u^P * LMRP$, $u^L * PMR$, $u^L * ERB(-1) * LMRP$. See also Lewbel (2005) to whom we are indebted for very useful discussions and suggestions on this issue.

ket regulation remains negative and significant and of similar value to the ones obtained so far. The main effect of $REGfdi$ remains negative and significant at the 5% level, using the specification with the lagged value of $WEDGE1$, and at the 10% level, using $WEDGE2$, although the absolute value of the coefficient is somewhat smaller Most importantly, the coefficients of the interaction terms remain negative and significant at the 1% level, when using $REGfdi$, and at the 5% level when using REG, and their absolute values are either similar or larger than before. Thus, for instance, the positive effect of deregulation (through REG) on employment is significant at the 5% level from the 60^{th} percentile of $LMRP$ and upwards. Quantitatively, the effect of deregulating the product market is smaller than the one obtained when one does not correct for endogeneity, but it remains always substantial when labor market regulation is high. Consider again a product market deregulation that, ceteris paribus, moves a country with high labor market regulation from the third quartile to the first quartile of REG, keeping labor regulation constant. It generates an employment gain of .60 percentage points on impact and 1.78 percentage points in the long run, using the results in column 1 of Table 4 (the figures were .82 and 2.82, using the results in column 1 of Table 1) Moreover, a one standard deviation decrease in regulation (REG), given $LMRP$, generates a long run gain in the employment rate of .74 percentage points in France (a high $LMRP$ country) versus 1.20 percentage points when one does not correct for endogeneity. In the case of Ireland (a low $LMRP$ country) the effect is minuscule in both cases. Allowing for endogeneity and for the response of labor market regulation to product market regulation, the results in column 1 of Table 3 and 4 imply a long run increase in the employment rate of 1.34 percentage points, under the assumption that labour market regulation is low and equal to the first quartile of $LMRP$, instead of 1.95 with no correction for endogeneity. When labour market regulation is high and equal to the third quartile of $LMRP$, the employment gain following product market deregulation increases is now 4.40, instead of 5.74. In summary, these results support the conclusions reached so far concerning the sign, statistical significance, and economic importance of the interactions between product and labour market regulation., although the size is slightly smaller when potential endogeneity bias is accounted for.

2.6 Conclusions

In this paper, we have provided a theoretical model and a detailed empirical analysis of the effects of product market deregulation, and its interactions with labour market policy settings, on employment outcomes. Our theoretical model includes a full specification of the fall back position of the unions and allows for union bargaining power to be endogenous and to depend on the market rents that firms enjoy. This provides a suitable framework for assessing the full set of interactions between product and labour market reforms, including those working through political economy linkages that were largely ignored by the previous empirical literature. To test the predictions of our model, we use a dynamic specification of the employment rate equation, which controls for fixed effects and country-specific trends and addresses explicitly both political economy linkages between policies and their endogeneity in the employment equation.

The results confirm that product market liberalization has produced substantial employment gains in OECD countries. Hence, there is evidence that policies aimed at increasing competitive pressures not only favorably affect productivity, but can also boost aggregate employment in reforming countries. A key result of our empirical investigation is that product and labor market deregulation can be classified as economic substitutes as regards their effects on employment: gains from reducing barriers to entry in product markets are larger when labor market policies are tight, thereby increasing the bargaining power of workers. This is an important conclusion from a policy perspective since it implies that in situations where labor market regulation is high and introducing more flexibility may prove to be difficult politically, deregulating the product market is an attractive option because it has a more favorable effect on employment at the margin.

Another important result is that employment gains from deregulation are underestimated if the political economy linkages between product and labour market policies are ignored. Results using summary measures of labor market policies that include both employment protection and the generosity of unemployment benefits we find that domestic product market deregulation has generated a decline in the bargaining power of workers, by promoting deregulation in the labor market or an easing of bargaining institutions, as captured by a measure that includes union density and coverage. From a political economy perspective, therefore, there is some evidence that product market deregulation can be considered as complementary to labor market deregulation. An implication of this result is that in assessing the effect of product market deregulation one should consider also its indirect effects through subsequent changes in labor market policies or institutions. In other words, deregulating product markets would imply a "double dividend" in terms of employment gains in the long run. In any case, the feedbacks between labour market policies and institutions and product market regulation deserve further discussion and investigation.

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2.8 Appendix A: Derivations

The (net) profit function for the firm, Π_i, is:

$$\Pi_i = \frac{P_i}{P} L_i - \frac{W_i}{P} L_i (1 + \tau^p) \tag{A1}$$

where $\frac{P_i}{P}$ denotes the price of the firm's product relative to the aggregate price level

Union utility in excess of the disagreement point is

$$V_i - \overline{V_i} = \left(1 - \tau^L\right) \left(\frac{W_i}{P} - \frac{W_i^A}{P} \right) L_i \tag{A2}$$

where $\overline{V_i} = \frac{W_i^A}{P} N_i$. The alternative wage is:

$$\frac{W_i^A}{P} = \frac{N - L - L^g}{N} \frac{B}{P\left(1 - \tau^L\right)} + \frac{L^g}{N} \frac{W^g}{P} + \frac{L}{N} \frac{W_i^o}{P} \tag{A3}$$

where L is aggregate employment, N the labor force, assumed equal to total union membership, L^g public employment. $\frac{B}{P}$ are unemployment benefits which are untaxed. $\frac{W^g}{P}$ is the government wage and $\frac{W^o}{P}$.the wage with another private employer. We will assume a balanced budget (and no public spending on goods):

$$\frac{B}{P} \frac{N - L - L^g}{N} + \frac{L^g}{N} \frac{W^g}{P} = \left(\tau^L + \tau^p\right) \frac{L}{N} \frac{W_i}{P} + \tau^L \frac{L^g}{N} \frac{W^g}{P} \tag{A4}$$

The first order conditions yield:

$$\frac{P_i}{P} = (1+\mu)(1+\tau^p)\frac{W_i^A}{P} \tag{A5}$$

$$\frac{W_i}{P} = (1+\mu\beta)\frac{W_i^A}{P} \tag{A6}$$

Using (A5) and (A6) and $\frac{P_i}{P} = 1$,and $\frac{W_i}{P} = \frac{W^o}{P} = \frac{W}{P}$ we can obtain (2.2) and (2.1) in the text. Using (2.2), the definition of the alternative wage, (A3), the assumption that private and government wages are equal, and the balanced budget condition, (A4), one can obtain an upward sloping relationship between the alternative wage and the employment rate,(2.3) in the text.

2.9 Appendix B: Data sources and definitions

Employment

Non-agricultural business employment rate

Definition: non-agricultural business employment as a share of the working-age population (15-64 group), in %

Source: Business employment and working-age population from OECD Analytical Database; agricultural employment and from OECD Labour Force Statistics.

Data adjustments: the share of agricultural employment in total employment in Labour Force Statistics was used to estimate an agricultural employment series consistent with the businessemployment series drawn from the OECD Analytical Database

Public employment rate

Definition: public employment as a share of the working-age population (15-64 age group), in %.

Source: OECD, Analytical Database;

Data adjustments: missing observations are obtained by linear interpolation when possible.

Product and labour market policies

Domestic Product Market Regulation

Definition: OECD summary indicator of regulatory impediments to product market competition in seven non-manufacturing industries. The data covers regulations and market conditions in seven non-manufacturing industries: gas, electricity, post (basic letter, parcel, express mail), telecommunications (fixed and mobile services), passenger air transport, railways (passenger and freight services) and road freight. Detailed qualitative and quantitative data on several dimensions of ownership, regulation and market or industry structure are coded and aggregated into synthetic indicators that are increasing in the degree of restrictions to private ownership and competition. Dimensions covered are degree of public ownership, legal impediments to competition, degree of vertical integration of natural monopoly and competitive activities in network industries, market share of incumbent or new entrants in network industries, price controls in competitive activities. The data are yearly over the 1975-2003 period and cover 21 OECD countries.

Source: Conway and Nicoletti (2006). The underlying data and the indicators are available online at www.oecd.org/eco/pmr .

Foreign direct investment restrictions

Definition: OECD summary indicator of restrictions to entry and post-entry restrictions to foreign direct investment in business services (legal, accounting, architecture, engineering), telecommunications (fixed and mobile), construction, retail and wholesale distribution, finance (insurance and banking), hotels & restaurants, transport (air, maritime, road), electricity and manufacturing. Restrictions cover limits on foreign equity ownership, constraints on business operation and obligations to undergo screening procedures. The data are collected every 5 years over the 1980-2005 period and cover 30 OECD countries.

Source: Golub (2003) and Golub and Koyama (2006).

Data adjustments: Intermediate years are interpolated.

Average unemployment benefit replacement rate

Definition: average unemployment benefit replacement rate across two income situations (100% and 67% of APW earnings), three family situations (single, with dependent spouse, with spouse in work) and three different unemployment durations (1st year, 2nd and 3rd years, and 4th and 5th years of unemployment).

Source: OECD, Benefits and Wages Database.

Data adjustments: original data are available only for odd years. Data for even years are obtained by linear interpolation.

Tax wedges on labour use:

WEDGE1:

WEDGE1 is constructed using tax revenue data from National Accounts and includes indirect taxes. The tax wedge is calculated in two different ways depending on whether social security contributions are deductible or not from taxable income [42]:

A: If social security contributions are not not deductible:

$\tau_l = (\tau_H$ * W + 2100 + 2200 + α * 2400 + 3000)/(WSSS + 3000)

where:

α = W /(OSPUE + PEI +W) = share of labour income in household income

Tax ratio for total household income:

τ_H= 1100/(OSPUE + PEI + W)

B: If social security contributions are deductible:

$\tau_l = (\tau_H$ * (W - 2100 - α* 2400) + 2100 + 2200 + α * 2400 + 3000)/(WSSS + 3000)

α = (W-2100)/(OSPUE + PEI + W-2100-2300)

τ_H = 1100/(OSPUE + PEI + W - 2100 – 2300 – 2400)

In both cases the tax ratio on consumption, τ_c is expressed as follows:

τ_c = (5110 + 5121 + 5122 + 5123 + 5126 + 5128 + 5200 – 5212)/(CP + CG – CGW)

Tax ratio on labour income and consumption combined, $\tau_{lc}(WEDGE1)$:

$\tau_{lc} = \tau_l$ + (1 - τ_l) * τ_c

Notes:

[42] While in most countries households are able to deduct social security contributions from their taxable income, this is not always the case. Among the 20 countries in the sample, Australia, Canada, Portugal, the United Kingdom and the United States have non-deductible social security contributions. In Germany and Ireland deductions are for a flat amount.

The tax revenue data are from the OECD Revenue Statistics. In particular:

• 1100 Taxes on income, profits and capital gains of individuals or households.

• 2000 Total social security contributions (2100 is paid by employees; 2200 by employers; 2300 by the self-employed and persons outside of the labour force; 2400 is unallocated).

• 3000 Taxes on payroll and workforce.

• 5110 General taxes on goods and services (5111 VAT).

• 5120 Taxes on specific goods and services (5121 excise taxes; 5122 profits of fiscal monopolies; 5123 customs and import duties; 5125 taxes on investment goods; 5126 taxes on specific services; 5128 other taxes).

• 5200 Taxes on use of goods and performances [5212 taxes on motor vehicles paid by others (i.e. other than households)].

The variables from National Accounts are:

• CP Private final consumption expenditure.

• CG Government final consumption expenditure.

• CGW Government final wage consumption expenditure.

• IG Investment by general government.

• OSPUE Unincorporated business net income (including imputed rentals on owner-occupied housing).

• PEI Interest, dividends and investment receipts.

• W Wages and salaries of dependent employment.

• WSSS Compensation of employees (including private employers' contributions to social security and to pension funds).

• YPEPG Government interest payments.

Source: See Carey D. and J. Rabesona (2002), "Tax Ratios on Labour and Capital Income and on Consumption", OECD Economic Studies No35. Data used in the paper have been updated using the same methodology.

WEDGE2:

Definition: share of personal income tax and all social security contributions (net of social benefits) to total labour cost (wages and employers' social security contributions) and averaged over two family types (single household and a couple with a dependent spouse and two children, both family types earning 100% of an average worker income).

Source: OECD, Taxing Wages.

Employment Protection Legislation (EPL)

Definition: OECD summary indicator of the stringency for Employment Protection Legislation for:

Indefinite contract (regular) workers

Fixed-term contract (temporary) workers

All contracts (measured as a simple average of indefinite and fixed-term contracts).

Information on regular contracts include procedural inconveniences that employers face when trying to dismiss a worker; notice and several payments at different job tenures; and prevailing standards of and penalties for unfair dismissals. Information on fixed-term and temporary work agency contracts include: the objective reasons under which they can be offered; the maximum number of successive renewals; and the maximum cumulated duration of the contract. Detailed data sets were collected for end of 1980s, end of 1990s and 2003 for 30 OECD countries.

Source: OECD (2004).

Data adjustments: Less detailed information on the timing of EPL reforms was used to construct an yearly series over 1985-2003. The 1985 value was extrapolated back to 1980.

Labour market institutions

Degree of corporatism:

Definition: indicator of the degree of centralisation/co-ordination of the wage bargaining processes, which takes values 1 for decentralised and uncoordinated processes, and 2 and 3 for intermediate and high degrees of centralisation/co-ordination, respectively. The "low corporatism" dummy variable frequently used in this paper takes value 1 when bargaining is decentralised and uncoordinated and zero otherwise.

Source: OECD, Employment Outlook 2004.

Data adjustments: original data are five-year averages and classify countries in each period along a 0-5 scale from least to most "corporatist" countries. In the present paper, annual data have been reconstructed based on various sources on the timing of past changes in centralisation and/or co-ordination of wage bargaining. Furthermore, the indicator has been rescaled along a 1-3 scale. In this process, it has been assumed that wage bargaining in France predominantly occurs at the intermediate level, while original data describe it as a mix of firm-level and industry-level bargaining. For other countries, values 1, 2 and 3 correspond to values 1-2, 3 and 4-5 in the original dataset, respectively.

Union density

Definition: trade union density rate, i.e. the share of workers affiliated to a trade union, in %.

Source: OECD, Employment Outlook 2004.

Data adjustments: data for missing years are obtained by linear interpolation. Furthermore, original data are typically available until 2001 for most OECD countries. Extrapolations have therefore been made in order expand data availability up to 2003. These are mainly based on national sources but, in some cases, an assumption of unchanged union densities over the period 2001-2003 had to be made due to lack of data.

Union coverage

Definition: collective bargaining coverage rate, i.e. the share of workers covered by a collective agreement, in %. Data are available for 1980, 1990, 1995 and 2000.

Source: OECD, Employment Outlook 2004. For two countries – Greece and Ireland – data are not available from the OECD source and we have used data from Golden, Miriam; Peter Lange; and Michael Wallerstein. 2006. "Union Centralization among Advanced Industrial Societies: An Empirical Study." Dataset available at http://www.shelley.polisci.ucla.edu/. Version dated June 16, 2006. Data from this latter source are broadly comparable with those of the OECD for the other countries in our sample.

Macro-economic conditions

Output gap

Definition: OECD measure of the gap between actual and potential output as a percentage of potential output.

Source: OECD (2005) Economic Outlook 77.

Big economic crisis

Definition: Dummy variable set to 1 when output gap is larger than -4%.

Source: Dang et al. (2006).

Political institutions

Ideology left-of-centre government

Definition: Dummy variable set to 1 for when the political orientation of the government is left-of-centre. The dummy is based on an ideology variable, which is measured as a simple average of the chief executive's ideology and the average of the two main parties in the coalition (if applicable). Ideological scores were attributed as follow: 2 = right-of-centre, 1 = centre and 0 = left-of-centre. The dummy is set to 1 for when the average value of ideology is lower than 0.8.

Source: Dang et al. (2006) based on World Bank, Database of Political Institutions, 2004

Mature government

Definition: Dummy variable set to 1 for when government has been in office for more than two years.

Source: Dang et al. (2006) based on World Bank, Database of Political Institutions, 2004

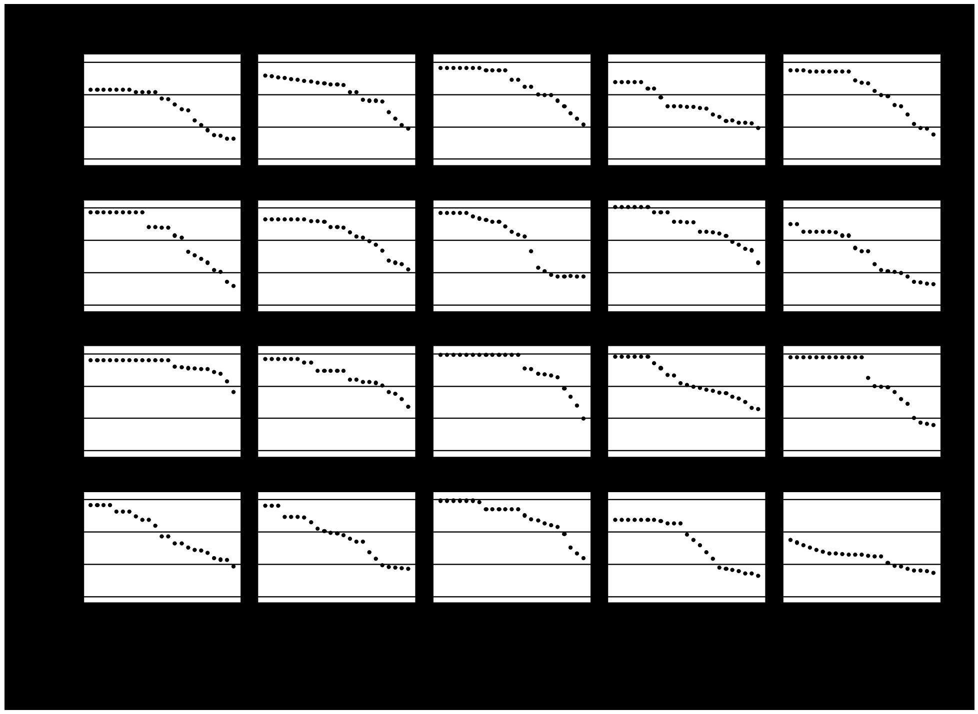

Figure B1: RNOPO (product market regulation without public ownership)

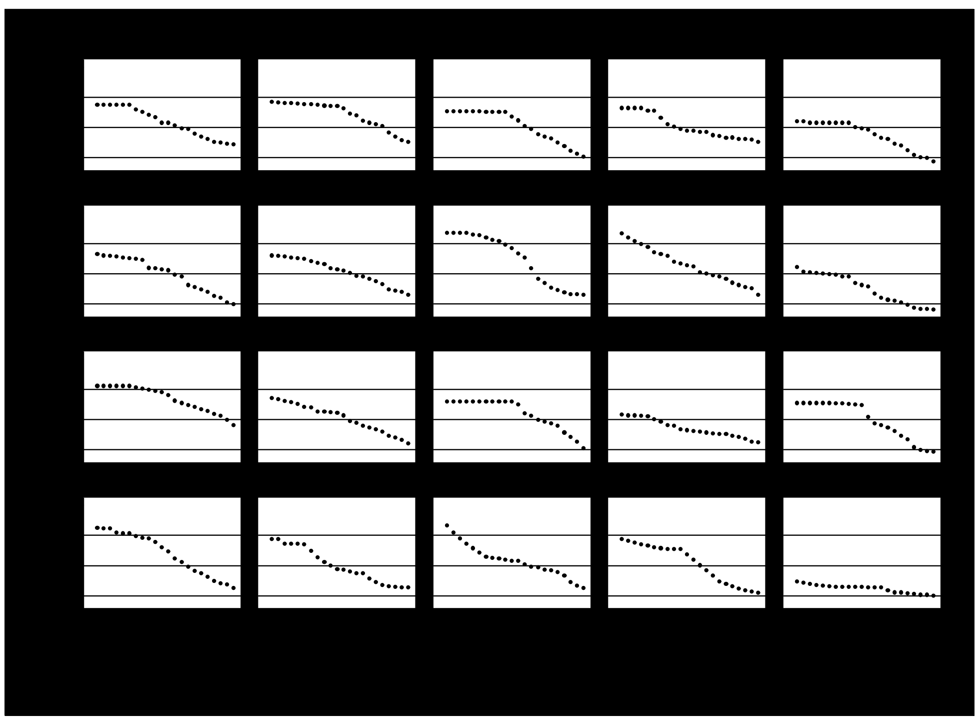

Figure B2: NOPOFI (First PC of RNOPO and FDI restrictions)

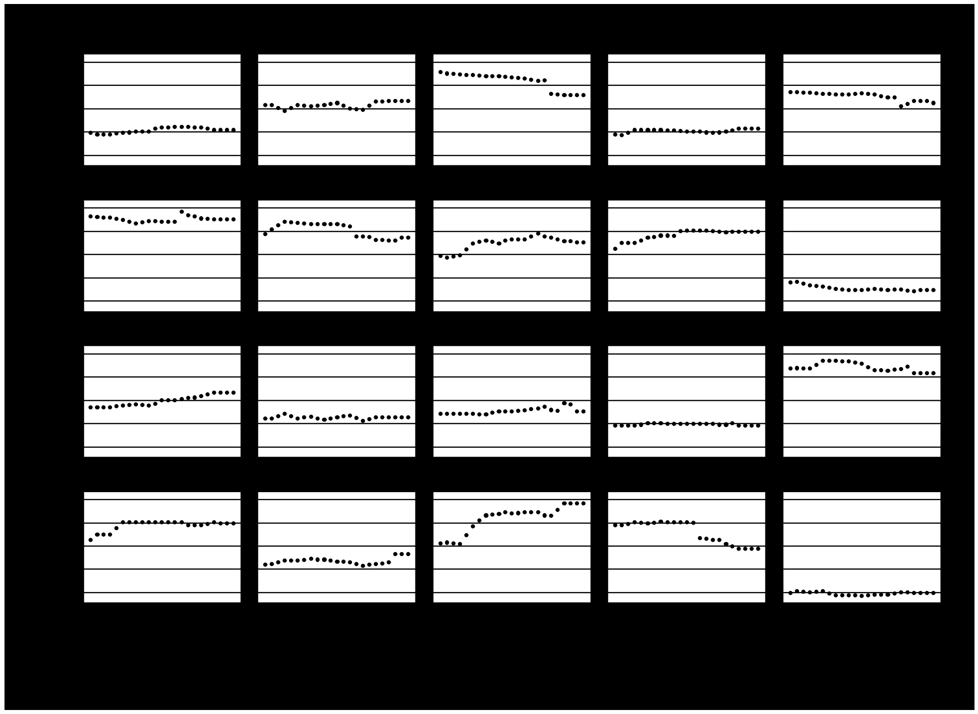

Figure B3: LMR (First PC of EPL and BEN)

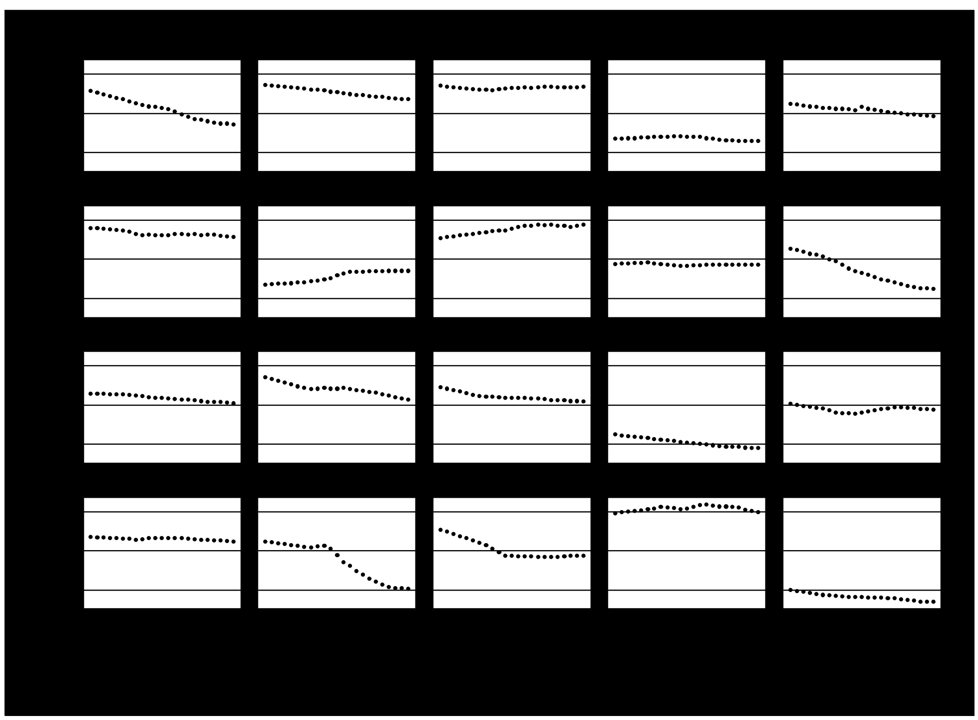

Figure B4: UDCO (First PC of union density and coverage)

Chapter 3

Macroeconomic Effects of Product and Labor Market (De)Regulation: The Long and the Short of Reforming Europe

3.1 Introduction- joint with M. Cacciatore

Product and labor markets in the Euro Area are characterized by high levels of regulation. **?** documents the presence of significant regulatory impediments to competition, stringent employment protection legislations and large unemployment benefits.

Public and academic debates often blamed thick regulation as responsible for the poor economic performance of many countries belonging to the Euro Area over the last thirty years. Concerns about the effects of strict regulation regard both unemployment outcomes and the ability of the economy to adjust to aggregate shocks.

Empirical evidence seems to support this view. Product market regulation (henceforth PMR) and labor market regulation (henceforth LMR) have been found significant determinant of unemployment outcomes: rigid PMR and LMR tend to increase unemployment rates (see **?**, **?** and **?**)) and their interaction amplifies individual direct effects (see **?**).

Empirical work has also established a connection between regulation and the size of economic fluctuations. **?**, **?** and **?** find that more stringent labor laws affects job flows over the business cycle - higher employment protection leads to lower labor reallocation. **?** shows that higher firing costs reduce aggregate output volatility, while **?** find a similar result from the presence of lower barriers to entry.

Existing theoretical literature has mainly focused on long run outcomes of PMR and LMR. Relatively little work has been done about the dynamic implications of regulation and its effect on business cycles fluctuations.

This paper develops a Dynamic Stochastic General Equilibrium model to study the *joint* effect of PMR and LMR for the aggregate behavior of the economy, both at long and short to medium run frequencies. We address three main questions: (i) What is the role of PMR and LMR for the steady state around which economies fluctuate? (ii) What is the short run adjustment following deregulation? (iii) What are the consequences of PMR and LMR for the dynamic response of the economy following aggregate shocks?

Our model features three main characteristics: endogenous determination of the number of producers in presence of sunk entry costs, labor market frictions and aggregate uncertainty.

The endogenous variation of monopolistically competitive producers is modeled as in **?** and **?**. To account for the empirical regularity that variation in the number of producers induces changes in the competitive environment we allow markups to endogenously vary due to demand side pricing complementarities. Labor markets are characterized by search frictions with endogenous job creation and destruction as in **?**, augmented with the introduction of firing costs.

Product market regulation is captured by the size of the sunk entry costs that firms have pay in order to access the market, reflecting administrative and regulatory barriers to business formation. Labor market regulation instead is proxied by the size of unemployment benefits and firing costs. We restrict our attention to these two dimensions of LMR since they are considered among the major contributors to the rigidity of continental European labor markets[1].

As in **?** and **?** our model will equate a producer with a production line for an individual good. In this framework each production unit is best interpreted as a production line with multi-product firms whose boundaries have been unspecified[2]. Production requires only labor inputs.

The model can be viewed as a large firm version of the Diamond, Mortensen and Pissarides (DMP) framework in which the number of producers endogenously varies together with the stock of labor. The number of firms that produce in each period can be interpreted as the capital stock of the economy since entry is financed by households through

[1]See for instance Bentolila and Bertola (1990), Yashiv (2004), Layard et al. (2005) and Ljungqvist and Sargent (2006).

[2]Empirically new products are not introduced only by new firms, but also by existing firms. **?** and **?** take a broad view of producer entry and exit as incorporating product creation and destruction by existing firms (although the model does not address the determinants of product variety within firms).

the accumulation of shares in the portfolio of firms that operate in the economy. The key interaction between labor and product market dynamics is captured by the stock market price of investment: it endogenously fluctuates in response to aggregate conditions and it summarizes the interdependence between expected profitability of production and labor market conditions - following aggregate shocks, labor market dynamics affects the entry decision which in turn feeds back into labor market outcomes. The interaction between PMR and LMR affects both entry profitability and the cost of reallocating workers from incumbents to newly producing firm.

From a theoretical point of view we show that linearity in production function, vacancy and firing costs are sufficient conditions to ensure a fully recursive structure of the model: there is no need to keep track of each cohort of new firms entering the market across time since the model still features a representative producing firms.

We find that high PMR and LMR can have significant consequences both for the mean level around which economies fluctuate and the response to aggregate shocks.

In the long run lower PMR is beneficial in terms of employment, wages and output. Deregulating LMR instead can have contrasting effects, hinging on the nature of the reform.

Lower PMR increases competition since lower barriers to entry attract a bigger number of firms on the market and reduce markups. Labor demand overall increases, leading to lower unemployment and higher wages, GDP and consumption. A reduction of unemployment benefits reduces wages by lowering workers' outside option in the bargaining process. As a consequence, profitability of entry and new matches increases. Employment and output rise, but wages are permanently lower. A reduction in firing costs instead impacts on the incentive to create and destroy jobs. On net the latter effect dominates. Wages increase, reducing entry profitability. Employment and output decreases.

When we perform a counterfactual exercise, assuming that the rigid Euro Area deregulates both PMR and LMR to the current US level, we find that a "global" reform would be beneficial: unemployment would be reduced and GDP, wages and consumption would increase.

Turning to the dynamic consequences of deregulation, we show that once the transitional adjustment to reforms is taken into account there might exist a trade off between short and long run outcomes. In the aftermath of a reduction in PMR consumption drops - entry of firms needs to be financed by households - and unemployment slightly rises - reallocating workers takes time in presence of frictions. Deregulating LMR involves a less significant intertemporal trade-off. Decreasing unemployment benefits boosts employment, production and consumption at any point in time during the transition, even though the wage reduction is sharper at the beginning of the reform. Reducing firing costs has a positive short run impact on business creation (higher entry of firms) which vanishes as time passes by.

Different levels of regulation seem to have sizable effects on the business cycles properties of the economy. Lower barriers to entry and lower replacement rates tend to smooth out aggregate fluctuations while lower firing costs have a reverse effect.

Lower barriers to entry compress steady state profits. A given change in aggregate productivity would induce a smaller change in incumbents' profits with a smaller impact on labor markets dynamics (the incentive to change vacancy posting would be lower). Smaller changes in labor market conditions would result in less variation of entry profitability, further dampening labor market dynamics. Deregulating labor market instead would affect the sensitivity of job creation and job destruction to aggregate shocks. Lower replacement rates would make the wage to absorb more of the productivity change, compressing the variation in entry profitability and dampening employment dynamics. At the opposite, higher firing costs would make job destruction more sensitive, amplifying the impact of disturbances on labor markets and preventing wages to fully absorb the shock. This would amplify entry dynamics.

When we consider a comprehensive deregulation of PMR and LMR (again by setting their values to the corresponding US level) we find that a more flexible Euro Area would adjust differently to aggregate shocks. The economy would experience a bigger response on impact and a quicker reversion to its steady state level. To gain some intuition, consider the effects of a negative, temporary, productivity shock. We show that in the rigid Euro Area the drop in productivity is mainly propagated through the slower initial response of the labor market (employment falls less due to the presence of higher firing costs and downsizing takes longer); at the same time, higher barriers to entry and unemployment benefits make entry and job creation to adjust more sluggishly, contributing to the slow recovery. In the more flexible Euro Area instead, employment would be cheaper to adjust, amplifying the size of fluctuations, and the recovery to the steady state would be much quicker, as reallocating resources would be less costly (due to lower entry costs and smaller unemployment benefits)

Our findings point out that concerns about the negative effect of strict regulation for the speed of recovery from downturns could be well placed. Furthermore, this finding is consistent with **?**, which document with a VAR analysis that countries in the Euro Area might be dynamically sclerotic.

To the best of our knowledge, this is the first work to investigate the *joint* effect, both at long and short to medium run frequencies, of product and labor market regulation. Previous theoretical work on the interplay between PMR and LMR developed static models to characterize the steady state effect of reforms. **?** highlight the channel through which PMR and LMR can affect labor market outcomes, focusing on the political economy aspects of such reforms. **?**, extend their work to quantitatively assess whether the observed decline in PMR in the US economy can explain the observed reduction in trend unemployment. **?** introduce productivity heterogeneity to analyze the impact of labour and product market (de)regulation on firm selection.[3]

Fewer contributions have investigated the impact of regulation for the business cycles properties of the economy. **?**, abstracting from the role of search and matching frictions, considers a real business cycle model with establishment level dynamics to analyze the effects of firing taxes on business cycle fluctuations. **?** focus on the role of labor market flexibility for the business cycle behavior and the transmission of monetary policy in the Euro Area, while **?** and **?** study the effects of labor market regulation on inflation volatility. All these papers abstracts from the role of PMR.[4]

A notable exception is **?** who considers the separate role of PMR and LMR for output and inflation dynamics. Differently from us, he assumes a constant number of producers in the economy, interpreting PMR as an increases of the elasticity of substitution across goods, with no role for the interaction between product and labor markets.

[3]For brevity, we omit from our literature review a large body of theorethical work linking labor market institutions and unemployment outcomes. See for example **?** and **?** and references therein for an overview of the effects of labor market policies, shocks and institutions on unemployment. For micro evidence on the employment effects of entry regulation see also **?**.

[4]In the paper we do not consider the role of nominal rigidities. We do so since our main goal is to study the joint effects of PMR and LMR on economic activity, abstracting from their interaction with other sources of rigidity. Cacciatore and Fiori (in progress) extend the present framework in this direction.

Our model is closely related to **?**. They introduce a sunk vacancy cost into a small firm version of the DMP model - one firm produces with one worker. In their model entry of workers into production coincides with entry of new producers. Under perfect competition in good markets and constant returns to scale, the one-worker firm assumption would be harmless, since the number and size of firms is indeterminate. Under monopolistic competition, as in our and their paper, firms size is determinate, and varies according to the demand elasticity faced by the firms among others. By retaining multiple worker-worker firms we are able to distinguish employment outcomes from the behavior of the number of producers in the economy. Furthermore, we can investigate the effects of deregulation both on intensive and extensive margin of production - changes in production of existing goods and in the range of available goods.

In Section 2 we present the model. Section 3 discusses the calibration. Section 4 discusses steady state and dynamics effects of deregulation. Section 5 focuses on business cycle implications of PMR and LMR. Section 6 concludes.

3.2 The Model

3.2.1 Household Preferences

The economy is populated by a unit mass of atomistic households. All contracts and prices are written in nominal terms and prices are flexible.[5] Each household is taught of as a large extended family containing a continuum of members along a unit interval. In equilibrium some members will be unemployed while some others will be producing. Members in each

[5] For this reason we do not model demand for currency and resort to a cashless economy as in **?**.

family perfectly ensures each other against variation in labor income due to employment or unemployment. There is no ex post heterogeneity across individuals.

The representative household maximizes the following utility function:

$$u(C) = E_t \left\{ \sum_{s=t}^{\infty} \beta^{s-t} \frac{C_s^{1-\gamma}}{1-\gamma} \right\}, \tag{3.1}$$

where C defines a basket of goods defined over a continuum Ω. At any given point in time only a subset of goods $\Omega_t \in \Omega$ is available. Let $p_t(\omega)$ be the nominal price for the good $\omega \in \Omega_t$. In order to account for the effects on the competitive environment introduced by product market regulation we depart from the standard CES specification for the consumer's preferences. Instead, we make use of the translog expenditure function proposed by **?**, which implies that mark ups inversely depend on the number of existing goods in the economy N_t[6]. The unit expenditure function is defined as:

$$\ln P_t = \frac{1}{2\sigma}\left(\frac{1}{N_t} - \frac{1}{\tilde{N}}\right) + \frac{1}{N_t} \int\limits_{\omega \in \Omega_t} \ln p_t(\omega) d\omega + \frac{\sigma}{2N_t} \int\limits_{\omega \in \Omega_t} \int\limits_{\omega' \in \Omega_t} \ln p_t(\omega)(\ln p_t(\omega) - \ln \ln p_t(\omega')) d\omega d\omega'.$$

where P_t is also the welfare based aggregate price index and N_t is the total number of products available for consumption at time t. $\tilde{N}$ corresponds to the mass of Ω.

3.2.2 Firms and Labor Market

There is a continuum of monopolistically competitive firms, each producing a different variety ω. Production requires only labor and it's characterized by constant returns to scale. We model labor market frictions within the context of a large firm set up, in order

[6] As N_t increases the demand elasticity increases, reducing markups.

to allow product and labor market regulation to affect both size and number of producing firms. Each firm employs a continuum of workers. The stock of labor varies because of the endogenous variation in the hiring (job creation) and separation (job destruction) rates. To hire a new worker firms have to post a vacancy incurring in a fixed cost κ - expressed in units of the aggregate consumption basket C_t. The probability of finding a worker depends on a constant return to scale matching technology, which converts aggregate unemployed workers U_t and aggregate vacancies V_t into aggregate matches M_t:

$$M(U_t, V_t) = \chi U_t^{\varepsilon} V_t^{1-\varepsilon}, 0 < \varepsilon < 1.$$

Defining labor market tightness as $\theta_t \equiv \frac{V_t}{U_t}$, each firm meets unemployed workers at a rate $q(\theta_t) = \frac{M(U_t,V_t)}{V_t}$. As in **?**, we assume that newly created matches become productive only in the next period. For an individual firm, the inflow of new hires in $t+1$ is therefore $q(\theta_t)v_t(\omega)$, where $v_t(\omega)$ is the number of vacancies posted by an incumbent ω.

Firms and workers can separate for exogenous and endogenous motives. When the firm finds a match to be no longer profitable, it can dismiss the worker but it has to incur a firing tax F[7], constant and proportional to the steady state wage: $F = \psi_F w^{SS}$.

Each filled job produces $Z_t z_{it}$ units of output, where i indexes a particular job. Production is subject to both aggregate and idiosyncratic shocks. Aggregate productivity Z_t is common to all firms, while a specific job's productivity z_{it} is idiosyncratic. Job-specific productivities are *i.i.d.* draws from a time invariant distribution with *cdf* $G(z)$, positive

[7] As in **?**, firing costs in this model take the form of a pure firing tax. Severance transfers from the firm to the worker have no allocative effects in the standard model with Nash wage bargaining, see e.g. **?**. Moreover, when the separation is exogenous, no firing cost is paid.

support and density $g(z)$.[8]

Total output of the ω producer is determined by the measure $l_t(\omega)$ of jobs, aggregate productivity and the aggregate over individual jobs:

$$y_t(\omega) = Z_t \int_{z^c(\omega)}^{\infty} z \frac{dG(z)}{1 - G(z^c)} l_t(\omega) \equiv Z_t \bar{z}_t(\omega) l_t(\omega), \tag{3.2}$$

where $z^c(\omega)$ is the (endogenous) critical threshold below which firms ω destroys non profitable jobs with $z_{it}(\omega) < z^c(\omega)$. This result in an endogenous job destruction rate $G(z_t^c(\omega))$.

Total *within* firm separation is given by $\rho_t^f(\omega) = \rho^x + (1 - \rho^x)G(z_t^c(\omega))$, where ρ^x is the fraction of jobs that are exogenously separated at the beginning of each period, identical across firms.[9]

The law of motion of employment for the producer ω is given by :

$$l_t(\omega) = (1 - \rho_t^f(\omega))(l_{t-1}(\omega) + q(\theta_{t-1})v_{t-1}(\omega)) \tag{3.3}$$

Endogenous entry of producers is modelled as in **?**. Prior to entry, firms face an entry cost $f_{E,t}$, to be specified later on. There are no fixed costs of production. Hence, all firms that enter the economy produce every period until they are hit by a "death" shock, which occurs with probability $\delta \in (0, 1)$ in every period (it follows that exit of firms is

[8] As common in the literature, the *i.i.d.* assumption is for analytical tractability. A more realistic assumption would be to allow the idiosyncratic shocks to display persistance. We conjecture that by departing from our assumption our results would not be significantly affected (see **?**).

[9] This assumption ensures that, in presence of small aggregate shocks, there are no corner solution with zero hiring in the firm's maximization problem.

exogenous in this model[10]). When a firm leaves the market, its entire stock of workers becomes unemployed, joining the pool of searchers in the next period. We assume that exiting firms bear no costs associated with the workers' layoff.

The timing of the model is as follows. At the beginning of time t :*(i)* aggregate productivity shock Z_t and idiosyncratic job specific shocks $z_i(\omega)$ are realized; *(ii)* entry decision by potential entrants is made; *(iii)* a fraction ρ^x of jobs are (exogenously) destroyed; *(iv)* incumbents endogenously destroy matches that became unprofitable; *(v)* all separated workers look for jobs and both new entrants and incumbent firms post vacancies; *(vi)* new matches are created (productive next period); *(vii)* individual wages are bargained between firms and producing workers; *(viii)* production takes place and *(ix)*, at the very end of period t, a fraction δ of all the existing firms exogenously leave the market.

Incumbent Firms

We start by describing the problem faced by a firm producing at time t. The incumbent ω minimizes the following cost function:

$$Cost_t(\omega) = E_t \sum_{s=t}^{\infty} \beta^{s-t}(1-\delta)^{s-t}(\frac{\lambda_{s+1}}{\lambda_s})\{\bar{w}_s(\omega)l_s(\omega) + kv_s(\omega) + G(z_t^c(\omega))F\},$$

subject to (3.3) and (3.2).[11] The first term of the cost function reflects the wage bill of the firm. Wages are not identical across workers , but depend on the idiosyncratic productivities of the jobs. Therefore, the $\bar{w}_s(\omega)$ is the aggregate of individual wages paid

[10] We abstract from the endogenous decision of firms to leave the market to preserve model tractability.

[11] Notice that each producer discount future expected costs taking into account the positive probability of exit in each period.

by the incumbent ω, taken as given by the producer. The second terms reflects vacancy costs and the third one corresponds to firing costs.

The first-order necessary conditions are:

$$l_t(\omega) : \phi_t(\omega) = \bar{w}_t(\omega) - \varphi_t(\omega) Z_t \bar{z}_t(\omega) + E_t \beta_{t,t+1}(\phi_{t+1}(\omega)(1 - \rho^f_{t+1}(\omega)); \tag{3.4}$$

$$v_t(\omega) : \frac{\kappa}{q(\theta_t)} = E_t \beta_{t,t+1}(\phi_{t+1}(\omega)(1 - \rho^f_{t+1}(\omega)) + G(z^c_t(\omega))F), \tag{3.5}$$

$$z^c_t(\omega) : \varphi_t(\omega) Z_t z^c_t(\omega) = w^c_t(\omega) - \frac{\kappa}{q_t} - F, \tag{3.6}$$

where $\beta_{t,t+1} = \beta(1-\delta)(\frac{C_{t+1}}{C_t})^{-\gamma}$is the stochastic discount factor adjusted for the exogenous exit probability and ϕ_t and φ_t are the Lagrange multipliers attached to the employment and output constraints, respectively. The multiplier ϕ_t gives the current period average value of workers for the incumbent ω. The multiplier φ_t is the contribution of an additional unit of output to the firm's revenue and it's equal to the firm's real marginal cost.

Each incumbent, due to the translog expenditure function, faces the following demand schedule:

$$y^D_t(\omega) = \underbrace{\sigma \ln(\frac{\widetilde{p}_t}{p_t(\omega)})}_{\text{mkt share}} Y_t \tag{3.7}$$

where $\ln \widetilde{p}_t = \frac{1}{\sigma N_t} + \frac{1}{N_t} \int\limits_{\omega \in \Omega_t} \ln p_t(\omega) d\omega$ is the maximum price that a producer can charge to have a positive market share and Y_t is the aggregate demand - expressed in units of the consumption basket C_t. Define $rp_t(\omega) = \frac{p_t(\omega)}{P_t}$ as the relative price of a variety ω. The firm maximizes the present discounted value of the stream of current and future real profits:

$$\Pi_t(\omega) = E_t \sum_{s=t}^{\infty} \beta^{s-t}(1-\delta)^{s-t}(\frac{\lambda_{t+s}}{\lambda_t})(rp_t - \varphi_t(\omega))y_t^D(\omega),$$

subject to (3.7). This yields:

$$rp_t(\omega) = \mu(N_t)\varphi_t(\omega),$$

where $\mu(N_t) = \frac{\eta_t(\omega)}{\eta_t(\omega)-1}$ is the endogenous mark up and $\eta_t(\omega) = \frac{d \ln y_t^D}{d \ln rp_t(\omega)}$ is the elasticity of substitution faced by the incumbent ω.

3.2.3 Wage Setting

The wage schedule is obtained through the solution of an individual Nash bargaining process.[12] The bargain solution splits the surplus of the match over the firm's and the worker's outside option. The analytical derivation of the wage scheduled is presented in Appendix, here we report the equilibrium wage resulting from the bargaining between a worker with a generic idiosyncratic productivity z and the producer ω:

$$w_t^z(\omega) = \eta(\varphi_t(\omega)Z_t z + \kappa\theta_t - E_t\zeta_{t,t+1}(\omega)F) + (1-\eta)B, \tag{3.8}$$

where $\zeta_{t,t+1}(\omega)$= $(1-p_t)E_t\beta_{t,t+1}\rho^f_{t+1}(\omega)$ and B is the unemployment benefit received by the worker if unemployed. We assume that $B = h_P + \psi_R \bar{w}^{SS}$, where the first term is

[12] Under CRS in production there is no difference between collective and individual wage bargaining.

home production and the second corresponds to a transfer from the government (ψ_R is the replacement rate).

The wage rate is increasing in labor market tightness, real marginal cost, aggregate and job specific productivity, while it's lower the higher the expected probability of firing the worker in the next period. The aggregate real wage is the average of the individual wages paid , weighted according to the distribution of idiosyncratic productivities:

$$\bar{w}_s(\omega) = \int_{z^c(\omega)}^{\infty} w(z) \frac{dG(z)}{1 - G(z^c)}. \tag{3.9}$$

The labor market structure of our economy can be summarized by a job creation equation, a job destruction equation and the expression for the aggregate wage rate (3.9). Combining (3.4) and (3.5) we get a standard job creation condition:

$$\frac{\kappa}{q(\theta_t)} = E_t \beta_{t,t+1}(1 - \rho^f_{t+1}(\omega))[\varphi_{t+1}(\omega) Z_{t+1} \bar{z}_{t+1}(\omega) - \bar{w}_{t+1}(\omega) + \frac{\kappa}{q(\theta_{t+1})}], \tag{3.10}$$

stating that the expected cost of posting a vacancy today - $\frac{\kappa}{q(\theta_t)}$- has to be equal to the expected marginal benefit. Evaluating the expression (3.8) at the cut off productivity $z^c_t(\omega)$ and using eq. (3.6), we can restate the job destruction equation as:

$$\varphi_t(\omega) Z_t a^c_t = [B + \frac{1}{1-\eta}(\eta \kappa \theta_t - \frac{\kappa}{q(\theta_t)} - (1 + \eta \zeta_{t,t+1}) F]. \tag{3.11}$$

This equation defines the cutoff productivity z^c_t, sufficient statistics for the behavior of the endogenous job destruction. At the margin, the producer has to be indifferent between maintaining the match and firing the worker.

3.2.4 Symmetric Equilibrium

In Appendix B we show that in equilibrium all the incumbents are identical regardless their timing of entry. In particular, we show that the reservation productivity cutoff z_t^c and the real marginal cost φ_t depend only on aggregate outcomes and hence are identical across all producers. As a consequences all prices and quantities are symmetric across firms[13]: $l_t(\omega) = l_t$, $\bar{z}_t(\omega) = \bar{z}_t$, $\bar{w}_t(\omega) = w_t$, $rp_t(\omega) = rp_t$, $e_t(\omega) = e_t$. Exploiting the symmetry across producers we can obtain a closed form solution for the elasticity of substitution across varieties $\eta_t(\omega) = \eta_t = 1 + \frac{\sigma}{N_t}$. This provides an expression for the endogenous mark up $\mu(N_t) = 1 + \frac{1}{\sigma N_t}$.[14] Finally, by imposing symmetry on the aggregate welfare based price index P_t, the relative price of each variety can be written as:

$$rp_t = e^{-\frac{\tilde{N} - N_t}{2\sigma \tilde{N} N_t}}.$$

An increase in the number of firms implies that the relative price of each good rp_t increases. When there are more firms, household derives more welfare from spending a given nominal amount, *i.e. ceteris paribus*, the price index P_t decreases.

3.2.5 Firm Entry and Exit

The entry-exit decision is modelled as in **?** and **?**. In every period there is a mass N_t of firms producing in the economy and an unbounded mass of perspective entrants. These entrants

[13] Firms with an identical marginal cost will charge the same relative price, facing the same demand schedule. Hence all the incumbents will produce the same amount. Recall that firm's output is given by $Z_t \bar{z}_t l_t$. Once we have proved that z_t^c is identical across all firms, then all firms on the market will have the same stock of labor l_t.

[14] As espected, as the number of producers N_t increases the mark up decreases.

are forward looking and correctly anticipate their future profits $d_s(\omega)$ in any period $s > t$ as well as the exogenous probability δ of incurring in the exit-inducing shock. Entrants at time t will start producing only from $t+1$.

An important aspect of the model is the way new entrants build their stock of labor in order to be able to start production. Given the timing of labor market, entrants have to post vacancies in t in order to begin production in $t+1$. In Appendix B we show that if all the producing firm are symmetric then it follows that the optimal hiring policy for a new entrant is to post vacancies to match the end of period size of incumbents.[15] This ensure that the model features a unique representative firm, as all the producers in each period are symmetric: we don't need to keep track of different cohorts of firms entering the market at different point in time.

Perspective entrants compute their expected post-entry value $e_t(\omega)$ given by the presented discounted value of their expected stream of per period profits d_s:

$$e_t = E_t \Sigma_{s=t}^{\infty} \beta_{s,s+1} d_s. \tag{3.12}$$

Prior to entry, firms face an entry cost $f_{E,t}$ to be paid in order to serve the market. It's made by two components:

$$f_{E,t} = f_{R,t} + \frac{\kappa}{q(\vartheta_t)} l_t.$$

The first term $f_{R,t}$ represents the sunk cost associated with regulation and barriers to entry. It's exogenous and subject to shocks.[16] It's expressed in units of the aggregate

[15] This follows after proving that all the producers have the same marginal cost in each period t regardless their timing of entry.

[16] Below we proxy product market deregulation as a permanent decrease in $f_{R,t}$.

consumption basket C_t: to pay for the regulation costs associated to entry each firm has to purchase a basket of materials which has the same composition as the consumption basket[17]. The second component of the entry cost reflects instead the cost of building the stock of labor required to start production in the next period. It's endogenous and it responds to aggregate labor market conditions. In particular it's procyclical: as the labor market is tighter (higher ϑ_t and hence higher $\frac{\kappa}{q(\vartheta_t)}$ - the expected cost of filling a vacancy) - *ceteris paribus* - entry is more costly due to a congestion externality generated by the presence of search and matching frictions in the labor market.

Entry occurs until firm value is equalized to the entry cost, leading to the free entry condition $e_t = f_{E,t}$.[18] Notice that in our model there is a clear link between the value of a firm e and labor market conditions. As labor market is tighter, the average firm value of the economy is higher. Given the time to build assumption, the law of motion of firms is given by $N_t = (1-\delta)(N_{t-1} + N_{E,t-1})$. The number of producing firms represents the stock of capital of the economy. It behaves much like physical capital in a standard RBC model, but it has an endogenously fluctuating price given by (3.12).

3.2.6 Household Budget Constraint and First Stage Budgeting

The representative household can invest in two types of assets: shares in a mutual fund of firms[19] and risk-free bonds. Let x_t be the share in the mutual fund of firms held by the

[17] We assume that the sunk regulation cost is paid in units of consumption for simplicity. An alternative would be to assume that $f_{R,t}$ is denominated in units of labor, as in **?** and **?**. Assuming that workers can be employed either in production of final goods or in the entry sector would complicate the model due to the presence of labor market fricitons without affecting our main results.

[18] This condition holds as long as the mass of new entrants $N_{E,t}$ is positive. We assume that macroeconomic shocks are small enough for this condition to hold in each period.

[19] New entrants finance entry on the stock market in this model.

representative household entering period t. The representative household buys x_{t+1} shares in a mutual fund of all the firms existing at time t - $N_t + N_{E,t}$ - even though only a fraction $(1-\delta)$ of those will be producing in $t+1$. The price of one share at time t is equal to the price of claims to future firms real profits e_t. The per period household's budget constraint can be written as:

$$B_{t+1} + C_t + e_t(N_t + N_{E,t})x_{t+1} = (1 + r_t)B_t + (d_t + e_t)N_t x_t + \bar{w}_t L_t + B(1 - L_t) + T_t, \quad (3.13)$$

where r_t is the real interest rate on bond holdings (known with certainty as of $t-1$), $B(1-L_t)$ represents the total amount of unemployment benefits and T_t are lump sum taxes. The household maximizes (3.1) subject to (3.13). The Euler equations for bond and share holdings are respectively:

$$1 = (1 + r_t)E_t\beta(\frac{C_{t+1}}{C_t})^{-\gamma} \text{ and } e_t = (1-\delta)E_t\beta(\frac{C_{t+1}}{C_t})^{-\gamma}(d_{t+1} + e_{t+1}).$$

3.2.7 Equilibrium

We are now able to characterize the equilibrium of our model economy. First, we derive aggregate variables in the labor market. Since new entrants optimally choose to have the same size of already existing firms and all producers destroy the same share of jobs z_t^c, aggregate employment can be expressed as $L_t = N_t l_t$. Total vacancies V_t are the sum of the vacancies posted by producing firms V_t^I and the vacancies posted by new entrants $V_t^E = N_{E,t}\frac{l_t}{q(\theta_t)} = \frac{N_{E,t}}{N_t}\frac{L_t}{q(\theta_t)}$. The law of motion of aggregate employment[20] can be written

[20] L_t represents the total number of workers which are producing at time t.

as:

$$L_t = \underbrace{(1-\rho_t^f)(1-\delta)}_{1-\rho_t^T}(L_{t-1} + q(\theta_{t-1})V_{t-1}),$$

where ρ_t^T is the economy wide total separation, reflecting both within and across firm job destruction. Accordingly, searching workers in period t are equal to the the currently stock of unemployed workers: $U_t = (1 - L_t)$. Gross job destruction, jd_t, is equal to $\rho_t^T L_t - \rho^x L_t q(\theta_t)$; gross job creation, jc_t, is $V_t q(\theta_t) - \rho^x L_t q(\theta_t)$. The second term in each expression is subtracted because it represents exogenous worker turnover. Total output produced by firms is used for consumption C_t, to pay for the regulation component of the entry cost $f_{R,t}$, and to create vacancies V_t :

$$Y_t = C_t + N_{E,t} f_{R,t} + \kappa V_t.$$

The aggregate resource constraint for the economy can be obtained by integrating the budget constraint (3.13) across households and imposing the equilibrium conditions $B_t = B_{t+1} = 0$, $x_t = x_{t+1} = 1$ and $B(1 - L_t) = T_t$,.

We get:

$$C_t + N_{E,t} e_t = N_t d_t + \bar{w}_t L_t.$$

Total consumption plus investment has to be equal to total income (labor income plus dividends). The model features 25 endogenous variables: $\beta_{t,t+1}$, $\zeta_{t,t+1}$, L_t, U_t, V_t, V_t^E, V_t^I, M_t, z_t^c, ρ_t, θ_t, $q(\theta_t)$, $p(\theta_t)$, $\bar{w}_t$, φ_t, rp_t, r_t, $\mu(N_t)$, N_t, $N_{E,t}$, d_t, e_t, Y_t, C_t $f_{E,t}$. The corresponding 25 equations are summarized in Table 1.

TABLE 1: MODEL SUMMARY

Adjusted Discount Factor	$\beta_{t,t+1} = \beta(1-\delta)(\frac{C_{t+1}}{C_t})^{-\gamma}$
Firing Cost Discount Factor	$\zeta_{t,t+1} = (1-p_t)E_t\beta_{t,t+1}\rho^f_{t+1}$
Within Firm Separation	$\rho^f_t = \rho^x + (1-\rho^x)G(z^c_t)$
Aggregate Employment	$L_t = (1-\rho^f_t)(1-\delta)(L_{t-1} + q(\theta_{t-1})V_{t-1})$
Aggregate Unemployment	$U_t = (1-L_t)$
Entrants Vacancies	$V^E_t = \frac{N_{E,t}}{N_t}\frac{L_t}{q(\theta_t)}$
Aggregate Vacancies	$V_t = V^I_t + V^E_t$
Matching Function	$M(U_t, V_t) = \chi U^{\varepsilon}_t V^{1-\varepsilon}_t$
Tightness	$\theta_t = \frac{V_t}{U_t}$
Job Finding rate	$p(\theta_t) = \frac{M(U_t,V_t)}{U_t}$
Vacancy Filling Rate	$q(\theta_t) = \frac{M(U_t,V_t)}{V_t}$
Aggregate Wage	$\bar{w}_t = \eta(\varphi_t Z_t \bar{z}_{t+1} + \kappa\theta_t - \zeta_{t,t+1}F) + (1-\eta)B$
Job Creation	$\frac{\kappa}{q(\theta_t)} = E_t\beta_{t,t+1}(1-\rho^f_{t+1})[\varphi_{t+1}Z_{t+1}\bar{z}_{t+1} - \bar{w}_{t+1} + \frac{\kappa}{q(\theta_{t+1})}],$
Job Destruction	$\varphi_t Z_t z^c_t = [B + \frac{1}{1-\eta}(\eta\kappa\theta_t - \frac{\kappa}{q(\theta_t)} - (1+\eta\zeta_{t,t+1})F]$
Mark Up	$\mu(N_t) = 1 + \frac{1}{\sigma N_t}$
Pricing	$rp_t = \mu(N_t)\varphi_t$
Variety Effect	$rp_t = e^{-\frac{\tilde{N}-N_t}{2\sigma\tilde{N}N_t}}$
Profits	$d_t = (1 - \frac{1}{\mu(N_t)})\frac{Y_t}{N_t}$
Entry Cost	$f_{E,t} = f_{R,t} + \kappa\frac{N_{E,t}}{N_t}\frac{L_t}{q(\theta_t)}$
Free Entry	$e_t = f_{E,t}$
Number of Firms	$N_t = (1-\delta)(N_{t-1} + N_{E,t-1})$
Euler equation (bonds)	$1 = (1+r_t)E_t\beta(\frac{C_{t+1}}{C_t})^{-\gamma}$
Euler equation (shares)	$e_t = (1-\delta)E_t\beta(\frac{C_{t+1}}{C_t})^{-\gamma}(d_{t+1} + e_{t+1})$
Aggregate Output	$Y_t = C_t + N_{E,t}f_{R,t} + \kappa V_t.$
Aggregate Accounting	$C_t + N_{E,t}e_t = N_t d_t + \bar{w}_t L_t.$

3.3 CALIBRATION

We interpret periods as quarters and calibrate the model to the Euro Area as of the end of 2007.[21] All Euro Area wide data are taken from the Area-Wide-Model database. We employ only quarterly data from 1997Q1 to 2007Q4 for the calibration. We do so since PMR and LMR were changing across the members of the Euro Area during the 80's and the beginning of 90's. Moreover, the index we employ for PMR is available for the year 1997. For this reason we set 1997 as the beginning of our sample[22].

As standard practice for quarterly business cycles models we set the discount factor $\beta = .99$ implying an annual real interest rate of 4%. The value of the risk aversion coefficient γ is equal to 2, while σ is chosen to produce a steady state markup of 10%. The implied steady state elasticity of demand - η - is equal to 11.[23] Pissarides (2003) compiles an index for entry delay as the number of business days that it takes (on average) to fulfill entry requirements, weighted by the number of procedures that must be performed. The entry delay index is reported in Table 3. We take the average value of the index across countries as a proxy for the Euro-Area. We follow the procedure in **?** to convert this index in months of lost output to get a value of f_R. The average value of the regulation index for the Euro area is 50.9 (days required to fulfill entry requirements) corresponding to 0.92 quarters of lost output (based on 220 business days in a year). Pissarides reports 8.5 days for United States. The implied value of f_R is 0.15.

Turning to the labor market we set the elasticity of the matching function $\varepsilon = .6$, a value consistent with the survey of estimates of the matching function for European countries reported by Pissarides (2003), ranging from $\varepsilon = 0.5$ to $\varepsilon = 0.7$. We select a mid point of these estimates.[24]

[21] The countries member at that time were: Austria, Belgium, Finland, France, Germany, Greece, Ireland, Italy, Luxemburg, the Netherlands, Portugal and Spain.

[22] We also recalibrated our model using a longer period of time, 1984 - 2007, in order to avoid possible concerns about the relatively short duration of the sample (44 observations). Our results are virtually unchanged and available upon request.

[23] In steady state - imposing the symmetric equilibrium - the elasticity of demand is given by $\eta = 1+N^{SS}\sigma$.

[24] This value is also consistent with recent evidence reported by **?** for Germany.

In order to calibrate the exogenous within firm separation - ρ^x- and the exogenous exit of plants - δ - we target the portion of job destruction due to the exit of plants and the ratio between job destruction and employment observed in the data. Empirical evidence suggests that job destruction - jd^{SS} - induced by the exit of plants ranges between 25 to 55 percents in countries belonging to the Euro area. At the same time job destruction flows range from 2.1% to 4.3% **?**. We set ρ^x and δ so that the exit of plants accounts for 40% of overall job destruction and the ratio jd^{SS}/L^{SS} is equal to 2,5%. Appendix C describes our procedure in detail.

The replacement rate is $\psi_R = 0.65$, an average of values reported in Table 3 taken from the **?** "Benefits and Wages" publication. The value for United States is .54.

Given $F = \psi_F w^{SS}$, we following **?** and set $\psi_F = .2$.

In absence of empirical guidance, the bargaining power of workers is set to a conventional value of $\eta = .5$.

Three labor market parameters are left to calibration. The cost of posting a vacancy κ, the flow value of home production h_P, the efficiency of the matching function χ. As common practice in the literature, we choose κ, h_P and χ in order to match the steady state unemployment rate U^{SS}, the probability of filling a vacancy q^{SS} and the total separation rate ρ^T. We set $U^{SS} = 9.2\%$ which is computed from quarterly data on unemployment. Total separation $\rho^T$is set to 3%. This values is an average value of the evidence collected for the Euro Area - see **?** for a thoughtful discussion. Finally, we set $q^{SS} = 0.7$, a value in line with estimates reported by **?** and **?**.

The idiosyncratic productivity shock z is lognormally distributed with mean υ and standard deviation σ_A. The parametrization of the latter follows **?**: we normalize υ to 0, calibrating σ_A to match the relative volatility of unemployment with respect to GDP.

The persistence of the AR(1) technology shock Z_t is set to 0.75, an average of available estimates for Europe (see **?**, **? ?**). The standard deviation of the technology innovation is chosen to reproduced the volatility of GDP observed in the data. Table 2 summarize our benchmark calibration.

TABLE 2: CALIBRATION SUMMARY

	Parameter	Value	Source/Target
Variety Elasticity	ϱ =	1.898	$\mu = 10\%$
Discount Factor	β =	.99	$r = 4\%$
Regulation Cost	f_R =	.85	*Data*
Plant Exit	δ =	.0125	$\frac{JD^{EXIT}}{jd} = .4$
Exogenous separation	ρ^x =	.0072	$\frac{JD}{L} = .025$
Replacement Rate	ψ_R =	$.65\overline{w}^{SS}$	*Data*
Firing Costs	ψ_F =	$.2\overline{w}^{SS}$	*Data*
Elasticity Matching Function	ξ =	.6	*Lit*
Workers Bargaining Power	η =	.5	*Lit*
Home Production	hp	.301	$U^{SS} = 9.2\%$
Matching Efficiency	χ =	.421	$q^{SS} = .7$
Vacancy Cost	k =	.068	$\rho^{Tot} = .03$
Std Idiosyncratic Shock	σ_A =	.38	σ_U/σ_Y
Std Aggregate Shock	σ_Z =	.0048	σ_Y
Persistence Aggregate Shock	ρ_Z =	.75	*Lit*

3.4 Steady State and Dynamic Implications of Deregulation

In this section we study the implications of reforming PMR and LMR in the Euro Area, focusing both on steady state and dynamic effects of deregulation. Previous contributions have mostly ignored the role of transition dynamics when evaluating the effects of reforms. Considering the adjustment of the economy following the implementation of each reform might reveal potential trade off between short and long run outcomes, with important consequences in terms of welfare.

We identify product market deregulation as a permanent decrease in the size of the regulation component f_R of the entry cost. Labor market deregulation is either a permanent reduction in the size of unemployment benefits - ψ_R- or a drop in firing costs - ψ_F.

In all the exercises we keep the other parameters of our model economy constant, recomputing the new steady state implied by variations in each dimension of regulation. Furthermore, we restrict ourselves to a perfect foresight exercise, assuming that no other aggregate shocks hits the economy after the unexpected, permanent change in PMR or LMR.[25]

3.4.1 Long Run Effects

In Appendix B we illustrate how to compute the steady state of our model economy.

The steady state level of the unemployment rate can be written as:

$$U = \underbrace{(\Upsilon_o + \Upsilon_1 G(z^c))}_{\text{Job flows}} \underbrace{\chi\theta^{1-\varepsilon}}_{\text{Unemp. Duration}}$$

where Υ_o and Υ_1 are constants[26] and the two terms in which we decompose U have an economic interpretation. The first term reflects the size of steady state job flows and it's summarized by the behavior of the reservation productivity z^c, while the second expresses unemployment duration as function of labor market tightness θ. Unemployment is increasing in both terms. The effects of policy reforms on equilibrium unemployment depends on their relative impact on θ and z^c, i.e. in relative shifts of job creation and job destruction curves. The two curves can be written as:

$$\text{JC curve} : \frac{\kappa}{\chi}\theta^{-\varepsilon} = (1-\eta)\beta(1-\delta)(\underbrace{\Phi(N(\theta, z^c)}_{\text{Variety Effect}}(\bar{z} - z^c) - F)$$

where $\Phi(N) = \frac{\sigma N(\theta,z^c)}{1+\sigma N(\theta,z^c)} e^{-\frac{\tilde{N}-N(\theta,z^c)}{2\sigma \tilde{N} N(\theta,z^c)}} = \frac{rp(N)}{\mu(N)}$ and $\frac{\partial\Phi(N)}{\partial N}_{|(\bar{\theta},\bar{z}^c)} > 0$,

$$\text{JD curve} : z^c = \underbrace{\frac{1}{\Phi(N(\theta, z^c)}}_{\text{Variety Effect}}(\frac{\eta}{1-\eta}\kappa\theta - \kappa\theta^{-\varepsilon} + B + (1+\eta\zeta_{t,t+1})F).$$

[25] In the next section we turn to the implication of regulation for business cycles fluctuations.

[26] Namely, $\Upsilon_o = \delta + (1-\delta)\rho^x$ and $\Upsilon_1 = \delta + (1-\delta)(1-\rho^x)$.

With respect to a standard large firm model with a fixed number of producers, there is an extra term appearing in both JC and JD curves, $\Phi(N)$ - which we call variety effect - affecting both z^c and θ. As N increases, the real marginal benefit of a match increases (as rp increases) leading, ceteris paribus, to a decrease of the reservation productivity z^c(each existing match becomes mor valuable as competition increases). At the same time, higher N, by impacting on vacancy posting, makes labor market tightness θ higher.[27]

Figure 1 draws JC and JD for a given value of N. JC curve is downward sloping. A lower reservation productivity z^c implies that the expected life of a match is higher because the probability of job destruction decreases (as z^c decreases). As a consequence firms create more jobs leading to an increase in market tightness. JD is upwards sloping because at higher θ the workers' outside option is higher and so more marginal jobs are destroyed.

In Figure 2 we plot the steady state effect of deregulating $f_R t$, ψ_R and ψ_F on the unemployment rate U, the total number of producers N, the wage rate w and firm size. We consider progressive reductions in each parameters, starting from their original values in the benchmark calibration. The continuous line in Panel A reports the net change in unemployment following the reform. The dashed line instead illustrates the effects of a deregulation in PMR (LMR) when LMR (PMR) has been already deregulated. The latter exercise investigates whether the model is consistent with the empirical findings that deregulation is more powerful in presence of other rigidities (see **?**).

Overall regulation has important effects for the mean around which an economy fluctuates. PMR has a positive effect on unemployment and wages in the long run. These effects are consistent with the empirical findings reported in **?** and with the prediction in **?**. A smaller entry cost increases the number of producers in the market, making the economic environment more competitive. Entry of firms feeds back into labor market outcomes. JC curve shifts to the right, increasing tightness θ. At the same time JD curve shifts down,

[27] Of course, N depends on general equilibrium conditions and hence it depends on θ and z^c, Equaiton SS(1) described in Appendix implicitely defines N as a function of θ and z^c. Unfortunately we cannot sign $\frac{\partial \Phi(N)}{\partial \theta}$ and $\frac{\partial \Phi(N)}{\partial z^c}$.

since as N and θ increase the continuation value of existing matches is higher and incumbents destroy less marginal jobs (overall the threshold z^c decreases). As the reservation productivity z^c falls and tightness θ rises unemployment declines. Aggregate wages, GDP and consumption increase.

Lower replacement rates lower unemployment and wages. JD curve shifts to the right: as the outside option of workers decreases, the average wage decreases. Ceteris paribus, lower wages induce incumbent firms to reduce firing since now it's less costly to keep low productive workers. Entry in the new steady state is higher as the decrease in aggregate wages rises profitability despite a bigger entry costs - entrants need to post more vacancies to build a larger stock of labor to begin production. Higher N boosts tightness. Employment is permanently higher, together with GDP and consumption.

Lowering firing costs shifts up JD. The savings from keeping a marginal, low productive worker, are now smaller and firms have an incentive to destroy more jobs. JC curve shift to the right, since hiring new workers it's now easier and more profitable. The reservation productivity z^c unambiguously increases. On net tightness θ is lower and U rises. Aggregate workers' productivity increases. The latter effect dominates the reduction in θ and aggregate wages increase. Entry is negatively affected by the increase in wage, despite the smaller size of the entry cost. The productivity gain is not enough to overcome the increase in unemployment and both GDP and consumption fall.

Empirical evidence suggests that higher employment protection legislation (EPL) is positive correlated with unemployment rates in OECD countries. We don't see our results about a reduction in firing taxes as conflicting with this empirical regularity since EPL[28] can be considered a broad measure of protection of incumbents which in the model is also captured by workers bargaining powers (which is indeed positively correlated with the unemployment rate). Furthermore, the ambiguous effect of a reduction of firing costs in a

[28] EPL includes two separate dimensions: a transfer from the firm to the worker to be laid off and a tax to be paid outside the job-worker pair. The transfer component is instead a set of administrative restrictions and procedures that the firm has to obey if it wants to lay off. In the model firing costs reflect any cost associated to firing which is not a transfer from the firm to the worker.

model *a la* Mortensen and Pissarides is a well known fact. As shown by **?**, the introduction of real wage rigidity reverts the previous result, making unemployment to increase with firing costs.[29] Our result is in line with the findings in **?**, **?**, **?** among others.

The last row of *Figure 2* shows the effect of an overall deregulation of PMR and LMR. Our counterfactual exercise assumes that the rigid Euro Area deregulates PMR and LMR to the current US level. We find that a "global" reform would be beneficial: unemployment would be reduced and GDP, wages and consumption would increase. Also competition would benefit as the overall number of firms on the market would increase, reducing steady state markups.

The dashed line in Panel A, reports the effects of deregulating PMR (LMR) when LMR (PMR) has been already deregulated. The intuition for this result is that PMR and LMR are highly interdependent. For instance, lowering PMR when LMR is rigid induces a bigger response of labor market. This happens because lower entry costs induce a bigger variation in N when the labor market is rigid as there are more resources to free up when the economy is overall more regulated. A bigger response of entry generates a larger reduction in unemployment.

3.4.2 Dynamic Effects

We now investigate the dynamic consequences of structural reforms for the Euro Area. We describe the dynamic adjustment of the economy to the new steady state following a 1% permanent decrease in the sunk entry cost f_R, in the replacement rate ψ_R and in firing costs ψ_F respectively.

Our dynamic exercise reveals that deregulating product and labor markets might present a trade off between short and long run outcomes. This is surely the case of a reduction in PMR: in the aftermath of the reform consumption drops - entry of firms needs to be financed

[29] To understand this observe that lower firing costs increase job creation rate. This positively affects the bargaining power of workers leading to a higher bargained wage. This tends to revert the positive effect on job creation. If wages are rigid, they increase less and the positive effects of firing costs on job creation wouldn't be offset.

by households - and unemployment slightly rises - reallocating workers takes time in presence of frictions. Deregulating LMR instead involves a less significant intertemporal trade-off. Decreasing unemployment benefits boosts employment, production and consumption at any point in time during the transition, even though the wage reduction is sharper at the beginning of the reform. Reducing firing costs has a positive short run impact on business creation (higher entry of firms) which vanishes as time passes by.

Figure 3 shows the effects of a decrease in PMR. The number of entrants overshoots its new steady state level since the expected value of entry is higher on impact. Incumbent firms begin to reduce their size by cutting job creation and increasing job destruction anticipating future reductions in markups and market shares. Total job creation increases on impact as potential entrants need to build their stock of labor. Unemployment rate slightly increases on impact since it takes time to relocate workers from downsizing incumbents to new entrants (it takes time to match a firm with new workers). Current consumption drops since entry needs to be financed by households.

As the number of firms in the market grows, markups and market shares drops, GDP rises and consumption starts to grow. Notably, the fraction of jobs endogenously destroyed reduces over time, as the value of a continuing match increases due to the congestion externality in labor markets. The aggregate wage rate steadily increases over time. Notice that given the sluggish response of N, the transitional effects of a reduction in PMR have longer lasting effects on labor market dynamics.

Figure 4 plots the dynamic adjustment following a 1% decrease in the replacement rate ψ_R. A lower value of ψ_R reduces the outside option of workers and wages drop on impact. Incumbent firms increase their size by increasing job creation and reducing job destruction. Pressure on the labor market increases tightness. Entry becomes relatively more expensive - new producers target a bigger average stock of labor to begin production and the expected cost of filling a vacancy it's higher. As a consequence N drops on impact. Unemployment decreases, consumption and GDP increase.

In the next periods, higher expected future profits - due to lower wages, higher markups and larger market shares - reverts the entry decision and N starts to increase toward its new (higher) steady state level. Aggregate job creation drops as the expected cost of filling a vacancy becomes too high for incumbents and competition it's fiercer. Job destruction also drops since higher tightness makes existing matches more valuable. Aggregate wage recovers but remains permanently lower than their initial level. Unemployment continues to drop, consumption and GDP to increase.[30]

Figure 5 shows the dynamic adjustment following a 1% permanent decrease in ψ_F. As the cost of firing a worker decreases, incumbents displace unproductive workers by rising the threshold z^c. This boosts aggregate productivity and aggregate wages overshoot their new steady state value. Tightness falls. The lower entry costs compensate the spike in the aggregate wage and on impact the number of entrants increases, as they target a lower, and cheaper to recruit, initial stock of labor. Job creation increases while job destruction drops. Overall unemployment rate increases as new (smaller) entrants do not compensate for the increased firing by incumbents. Aggregate productivity increases, but this is not enough to avoid a drop in output and consumption. As markups are reduced and aggregate demand is weaker, entry becomes negative, further increasing unemployment.

3.4.3 Welfare Consequences

The dynamic nature of our model allow us to calculate the welfare implications of deregulation taking into account long run outcomes as well as the transitional adjustment. Since our model features perfect risk sharing among family members and no ex post heterogeneity between employed and unemployed workers, our welfare calculations are meant to capture only aggregate implications of deregulation, while the presence of potentially important distributional conflicts cannot be addressed.

We calculate the fraction of aggregate consumption that would make the representa-

[30] The hump shamped response of the aggregate wage reflects the behavior of the labor market tightness. Notice that: $\widehat{\theta}_t = \widehat{V}_t - \widehat{U}_t$. On impact V is positive and U is negative. As V sharply declines, with U steadly declining, θ falls for a while. Vacancies drop after the initial period since incumbent have adjusted their size at the time of the reform by increasing posting to take advantage of the drop in entry.

tive household indifferent between not implementing the reform (consuming $\bar{C}^{\text{rigid}}$ in each period) and deregulating (consuming C_t - time varying until the economy reaches the new steady state - after the policy has been implemented:

$$\sum_{s=t}^{\infty} \beta^{s-t} \frac{[\bar{C}^{\text{rigid}}(1+\Delta)]^{(1-\gamma)}}{1-\gamma} = \sum_{s=t}^{\infty} \beta^{s-t} \frac{[C_t]^{(1-\gamma)}}{1-\gamma}, \tag{3.14}$$

where Δ is the percentage increase in steady state (pre-deregulation) consumption level that would make the household indifferent.

Our results show that: (i) for each point reduction in $f_{R,t}$ the household would require an increase in consumption of 0.16%. (ii) in the case of a decrease in the ψ_R, the compensation Δ amounts to 1.53%; (iii) a reduction of firing costs induces a negative compensation equal to -0.14% for each point reduction.

These results are in line with the findings previously highlighted: in terms of aggregate welfare, reducing replacement rates provides the biggest gain since it involves the smallest short run costs and the biggest long run gains. Firing costs, even distorting job creation and job destruction are beneficial in terms of welfare.

3.5 The Impact of Deregulation on Business Cycle Fluctuations

So far we have shown that regulation has important consequences for the mean level around which economies fluctuate. In this section we investigate whether regulation can also affect the cyclical behavior of the economy.[31] We pin down the size of reforms by considering changes of PMR and LMR that would set the value of entry cost f_R, replacement rate ψ_R and firing cost ψ_F to the current level of the United States.

We proceed as follows. First we show that the model can reproduce selected second moments of marcoeconomic aggregates of the Euro Area. Second we study the impact of

[31] We assume that technology shocks are the only driver of business cycles fluctuations.

each single reform for the dynamic response of the economy. Finally, we investigate the effects of an overall deregulation in f_R, ψ_R and ψ_F..

3.5.1 Benchmark Economy: Rigid Euro Area

Figure 6 describes the dynamic response of our benchmark economy to a 1% negative, persistent productivity shock.

On impact, as Z drops, the economy responds along its intensive margin - i.e. incumbent firms reduce production by (costly) increasing job destruction[32], as the reduction in aggregate productivity reduces profitability of existing matches. The unemployment rate increases, while tightness falls together with the aggregate wage. The entry decision is negatively affected, even though the entry cost is lower on impact. The number of new entrants decreases. This feeds back into labor market, further reducing job creation. Consumption and GDP decrease.

All the key variables of the model display an hump shaped pattern. Entry does not reach it's negative pick on impact as it would be in a model without labor market frictions (see **?**). Instead, since it takes time to downsize the stock of labor, the drop in employment is slow and production doesn't fall abruptly on impact. Unemployment continues to rise after the first period, while GDP and entry of new firms continue to drop.

The reduction in the number of producers increases markups and incumbents' market share. This effect paired with the gradual recovery in aggregate productivity Z_t makes entry to become positive. Vacancy posting it's now cheaper and incumbent firms start to create new jobs. Less marginal jobs are destroyed. Wages, GDP and consumption go back to their initial steady state level.

Variation in the number of plants and in the stock of workers are the key endogenous state variables for the propagation of aggregate shocks in our model. The presence of labor market frictions, sunk entry costs and time to build introduce internal persistence. Labor market frictions impact on the entry decision of producers - affecting both cost and

[32] Given the timing of the model, this is the only margin they can use to shred workers on impact.

profitability of entry. The sluggish variation in the number of producers feeds back into labor market outcomes, contributing to the propagation of the shock.

Second Moments To evaluate the business cycle properties of our model, we compute model-implied second moments for HP-filtered key macroeconomic variables and compare them to Euro Area data. The source of fluctuations is an aggregate productivity shock with persistence set at .75 (see details about its calibration in Section 5) and standard deviation of innovations equal to 0.0060 (chosen to match the volatility of GDP observed in the data).

The moments in our model are calculated on real variables deflated by a data consistent price index - i.e. for any variable X_t in units of consumption, the data consistent counterpart is obtained as $\frac{X_t}{rp_t}$.[33] Results are presented in Table 4.

Volatility of GDP and unemployment are matched by construction. The model is able to reproduce the volatility of wages, while it understate volatility of consumption[34] and overestimates volatility of investment. Even though data about vacancies and tightness are not available for the Euro Area, our model generates values relative to GDP that are in the range of those observed for Germany (see **?**). The model is also able to generate a negative Beveridge curve and a negative correlation between job creation and job destruction. We view this as a success, given the usual difficulty of the standard search and matching framework along these dimensions.

Our setup does reasonably well in replicating the contemporaneous correlation between output and the other macro variables. In particular, the model exactly replicates the contemporaneous correlation between GDP and unemployment. The endogenous persistence of variables, even if higher than a standard RBC model, is still lower than the one observed in the data.

The model is also able to generate countercyclical markups and procyclical profits.

Overall we consider the performance of our benchmark model as a relative success given

[33] See **?** for a comprehensive discussion.

[34] With this respect to consumption, our model faces the same well-known difficulty of the standard RBC model where consumption is too smooth relative to the data.

it's ability to reproduce several features of the Euro Area labor market.

3.5.2 Deregulation in PMR: reduction in f_R

In *Figure 5* we compare the dynamic adjustment of the economy when $f_R = .85$ - its baseline value for the Euro Area - against $f_R = .15$ - corresponding to barriers to entry in US.

Impulse responses reveal that higher product market regulation significantly amplifies the impact of aggregate disturbances. The same negative TFP shock induces a much bigger drop in GDP, consumption and market tightness on impact and a higher spike in the unemployment rate.

To gain some intuition about the effects of a higher level of f_R notice that lowering PMR makes the economy fluctuating around a steady state with a bigger number of firms of a smaller size. Hence on impact a more regulated economy experiences a bigger drop in current profits, inducing a bigger adjustment along the intensive margin (output per firm drops more). As a consequence unemployment is more responsive as the negative shock hits the economy.

Entry drops on impact because of the overall reduction of future profitability, but it drops less in the rigid economy. This happens because, for any given reduction in the future stream of profits, the entry cost drops more in the regulated economy, preventing entry to free fall.[35]

As firing workers is costly, it takes time to downsize the stock of labor. Consequently, the size of new entrants doesn't reach it's negative peak on impact but it continues to shrink in the following periods.[36] As the economy starts to recover from the negative shock, the presence of labor market imperfections further amplifies the effects of higher barriers to entry, making the rigid economy to adjust at a lower pace. As a bigger number of workers has been displaced on impact, it takes longer time to employment to recover and

[35] The bigger drop in the size of incumbents and the bigger reduction in market tightness affects the entry cost faced by potential new entrants. In the rigid economy the expected cost of filling a vacancy is much lower and the stock of labor required to begin production much smaller.

[36] Instead, with a more flexible PMR the required change in the size of incumbents is zero and output per firm recovers faster.

entry profitability stays lower for a longer time. For this reason unemployment, GDP and consumption recover more slowly.

3.5.3 Deregulation in LMR: reduction in ψ_R

Figure 6 shows the impact of a reduction in the size of the replacement rate, from its actual average level $\psi_R = 0.65$ to the US level $\psi_R = 0.54$.

As discussed before, a lower replacement rate decreases job destruction rate in the steady state, where the latter is given by the fraction of jobs below the job destruction threshold z^c. Empirically, this threshold is situated in the left tail of the distribution of idiosyncratic job productivities. As a result, in economies with higher ψ_R and a lower steady-state productivity threshold, there are fewer jobs in the neighborhood of the threshold, which causes job destruction to be less sensitive to shocks. This explains why unemployment responds less in the flexible economy following a shock. At the same time a lower replacement rate makes the outside option of workers worse, contributing to the reduction in flows out of employment and making the real wage more responsive. Also GDP and consumption fall less on impact.

The behavior of entry is qualitatively similar to the case of a reform in f_R. - $N_{E,t}$ drops less on impact in the rigid economy. Lower wages and unemployment make the flexible economy to recovers faster, boosting producers' entry and labor demand.

Comparing the role of higher replacement rates with respect to higher barriers to entry it should be noted that even if the dynamic response of key macroeconomic aggregates are qualitatively similar, their behavior arises from different steady state effects of the two reforms. Lower ψ_R significantly affects the mean reservation productivity around which the economy fluctuates. Job destruction becomes acyclical and aggregate wages more volatile, impacting on entry profitability. Lower f_R compresses steady state profits making the economy less sensitive to aggregate shocks. This in turn induces job destruction and job creation to responds less.

3.5.4 Deregulation in LMR: reduction in ψ_F

In *Figure 6* we show how differences in the size of the firing costs affect the propagation of the aggregate productivity shock. We let ψ_F to vary from its benchmark value $\psi_F = .2$ to $\psi_F = 0$.

The steady state effect of a reduction in ψ_F is opposite with respect to the change in ψ_R. Lower firing costs induce a bigger destruction of marginal jobs, i.e. the productivity cut off shifts up, increasing the mass of marginal workers. For a given aggregate shock, incumbent firms can now costlessy downsize. As a consequence unemployment spikes with respect to the presence of positive firing costs. Also GDP and consumption suffer a much bigger reduction. Entry of producers in this case drops more in the flexible case. The bigger reduction in the workforce reduces production and expected profits. The recovery in this case it's longer in absence of firing costs, since the initial drop in output and consumption propagates for a longer period of time.

3.5.5 A Flexible Euro Area

We conclude our analysis by addressing the consequences of an overall reform of PMR and LMR in the Euro Area. In the previous section we have documented that these reforms might have contrasting impact on the way the economy would adjust following partial reforms. In particular we have shown that reducing barriers to entry and replacement rates might reduce the size of economic fluctuations, while lower firing costs might have a reverse effect. For this reason we compare our benchmark economy pre and post a reform which would set both PMR and LMR to the current level of US.

Our findings suggest that an overall deregulation would make the Euro Area to adjust differently to aggregate shocks. After a negative productivity shock the rigid economy suffers a less severe downturn. This is mainly due to higher firing costs which prevents a sharp decline in employment. As a consequence production and consumption drop less on impact compared to a flexible scenario. High regulatory barriers reduce profitability of entry at any point in time during the transition, while higher unemployment benefits prevents wages to fully absorb the negative productivity shock, further reducing job creation. Entry and employment adjust at a much slower pace with respect to the flexible case.

In the rigid Euro Area negative aggregate productivity shocks are propagated through the slower dynamic response of the labor market, amplified by the effects of higher barriers to entry and replacement rates. In a flexible Euro Area instead, employment would be cheaper to adjust on impact, amplifying the size of fluctuations, but the recovery to the initial steady state would be much quicker, as reallocating resources would less costly.

Our findings are consistent with the VAR analysis in ?: the Euro Area seem to be dynamically sclerotic, regardless the size of the steady state labor market flows. Overall, higher regulation somehow protects the economy after a negative shock, but this comes at the cost of a longer economic downturn, as the recovery is slower.

3.6 Conclusions

We developed a model with an endogenous number of producers subject to sunk entry costs and labor market imperfections to study the joint role of product and labor market regulation both at long and short to medium run frequencies.

In the model barriers to producer entry and frictions in the reallocation of workers constitute the key, novel, aspect of our theoretical framework. The model matches a set of stylized long run empirical facts linking PMR and LMR and it's consistent with several second moments of the Euro Area.

We have shown that high regulation characterizing product and labor market in the Euro Area has implications for the overall behavior of the economy.

Deregulating product markets would induce beneficial effects in terms of employment, wages and output in the long run, but the reform would come with transition costs in the short run. Reforming labor markets instead involves less intertemporal trade off, but our model predicts that lowering unemployment benefits and firing costs would produce opposite results. Smaller unemployment benefits would be beneficial in terms of employment and output, but would lower wages. Lower firing costs would trigger a positive effects on producer competition in the short run (stimulating entry), but this effect would be short lasting. Costlessy job destruction would undo the positive effect on job creation and on net employment and aggregate output would be lower. Wage instead would be higher.

If the Euro Area was about to implement a radical deregulation in product and labor markets, our model predicts net gains in terms of employment, wages, GDP and competition.

Regulation has also consequences the business cycle properties of the economy. Lower barriers to entry and lower replacement rates would tend to smooth out fluctuations, while firing costs would have a reverse effect. Importantly, we have show that a more flexible Euro Area would adjust differently to aggregate shocks. On impact, they would trigger a bigger response of the economy - in the labor market in particular . At the same time the system would return to its steady state at a much faster pace. This would happen because the net effect induced by lower barriers to entry, replacement rates and firing costs would make job creation and job destruction more sensible to aggregate conditions, inducing a quicker response of profitability of entry.

There are issues related to the role of regulation that we didn't explore in this paper but that we consider important and are left for future research.

First the model abstracts from the presence of other relevant rigidities, namely price and wage rigidities. Since we believe to have documented the importance of the interdependence of PMR and LMR for aggregate outcomes we think that studying the joint effect of PMR and LMR in the presence of sticky prices/wages might be of interest for the conduct of monetary policy in the Euro Area (see Cacciatore and Fiori (in progress)).

Second, in the model we assume no ex-post heterogeneity across agents and hence distributional issue are left aside from our analysis. Relaxing the assumption of perfect risk sharing might add a significant piece of information about the effects of PMR and LMR from welfare perspective.

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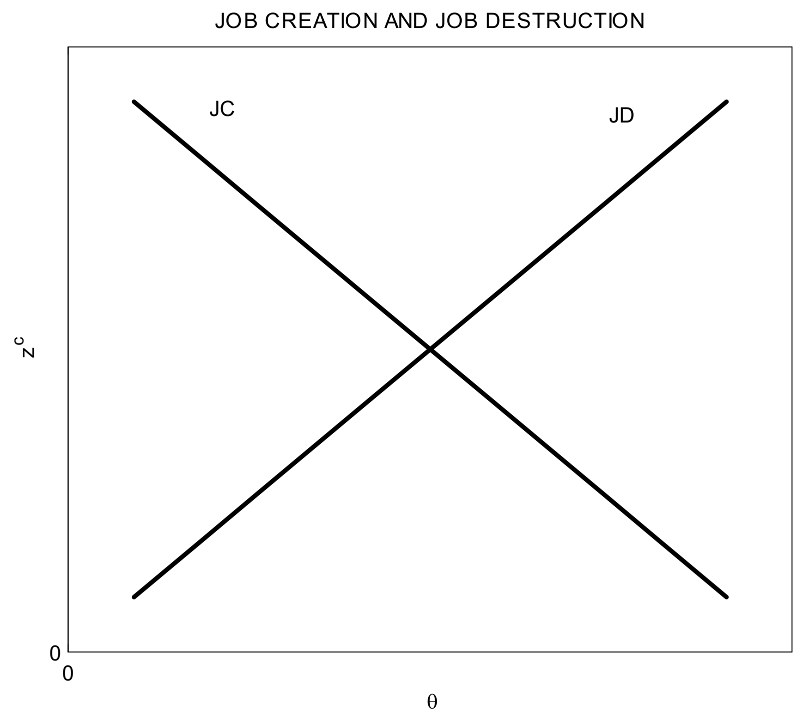

Figure 1. The plot of the job creation and job destruction curve.

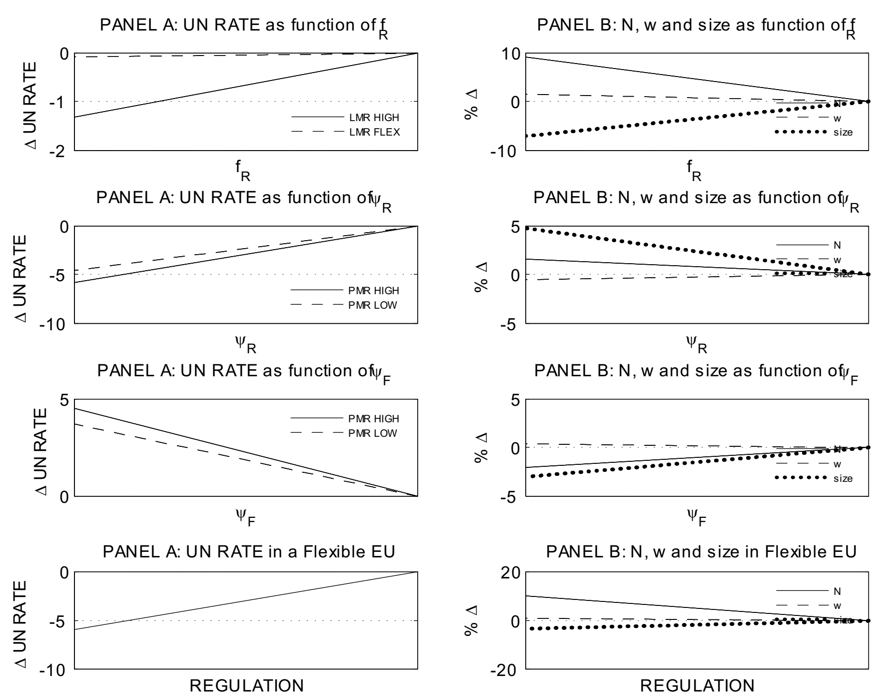

Figure 2. Steady state variation of the unemployment rate, N the number of firms, the

wage and firm's size under different packages of regulation. Regulation is lower closer to the origin.

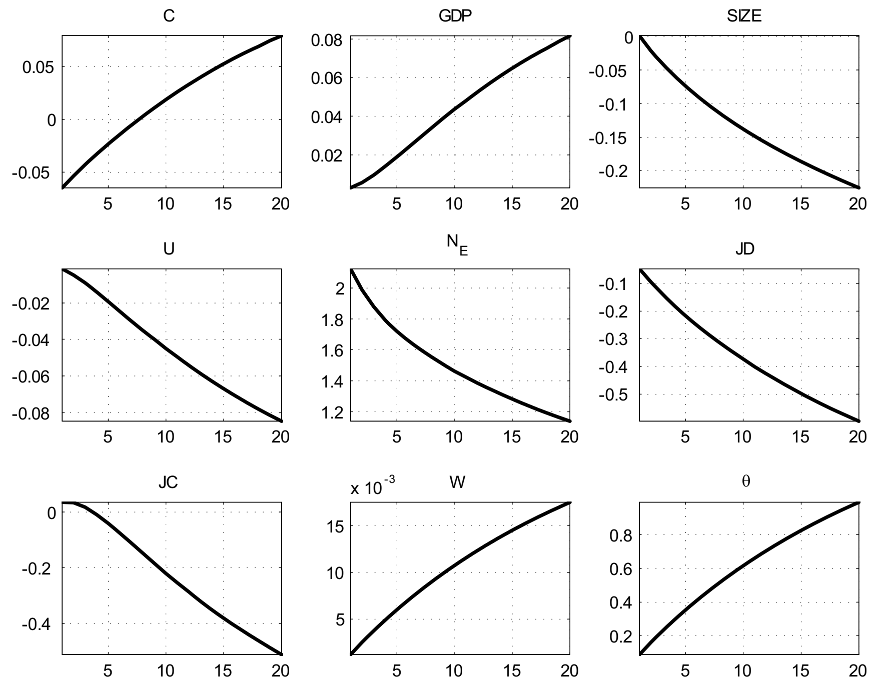

Figure 3. The impulse response function, as percentage deviations from steady state, following a permanent deregulation in PMR.

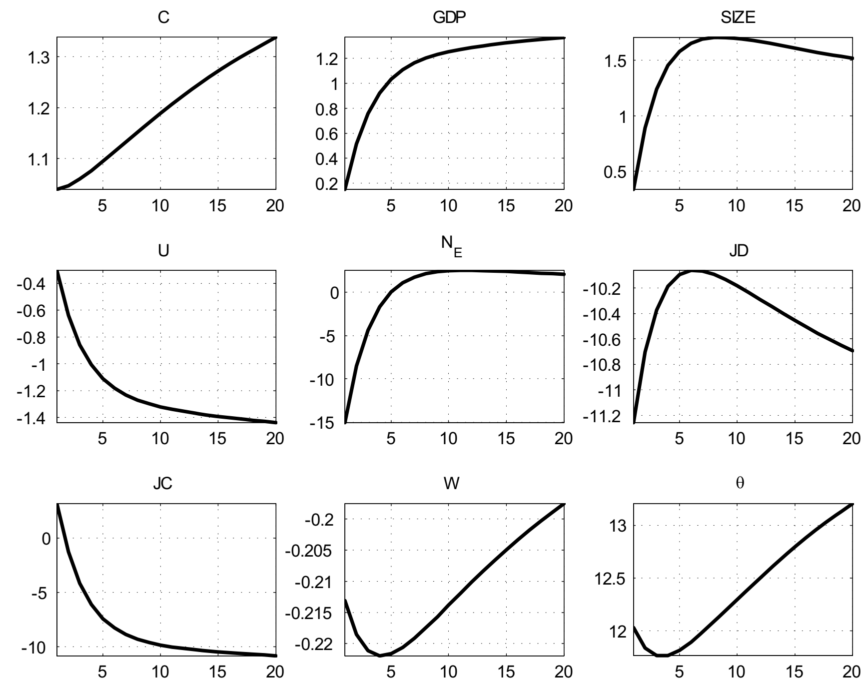

Figure 4. The impulse response function, as percentage deviations from steady state, following a permanent reduction in the size of the unemployment benefit ϕ_R.

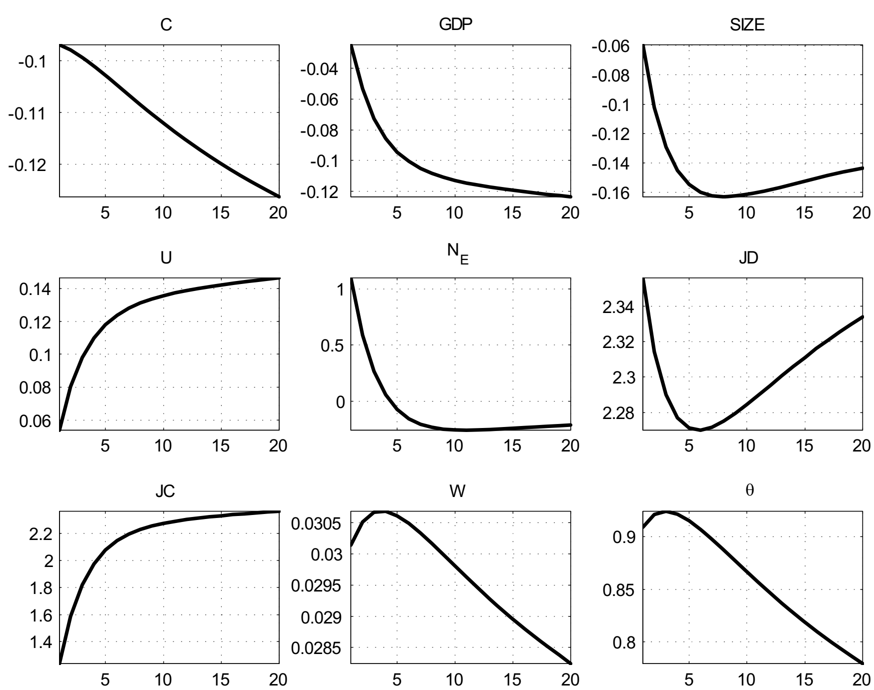

Figure 5. The impulse response function, as percentage deviations from steady state,

following a permanent reduction in the size of the firing cost ψ_F.

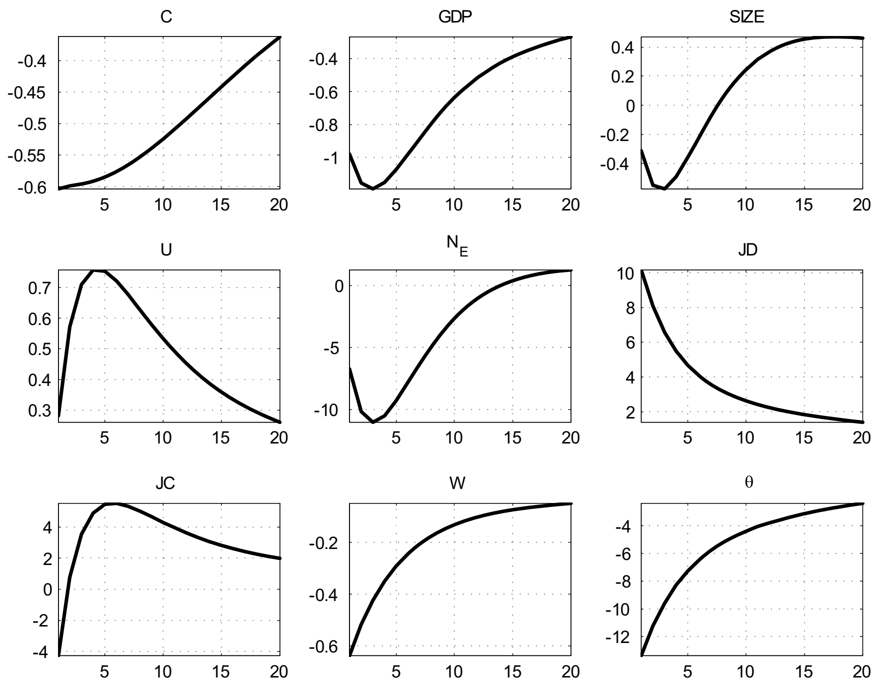

Figure 6. The impulse response function, as percentage deviations from steady state, following a persistent aggregate productivity shock.

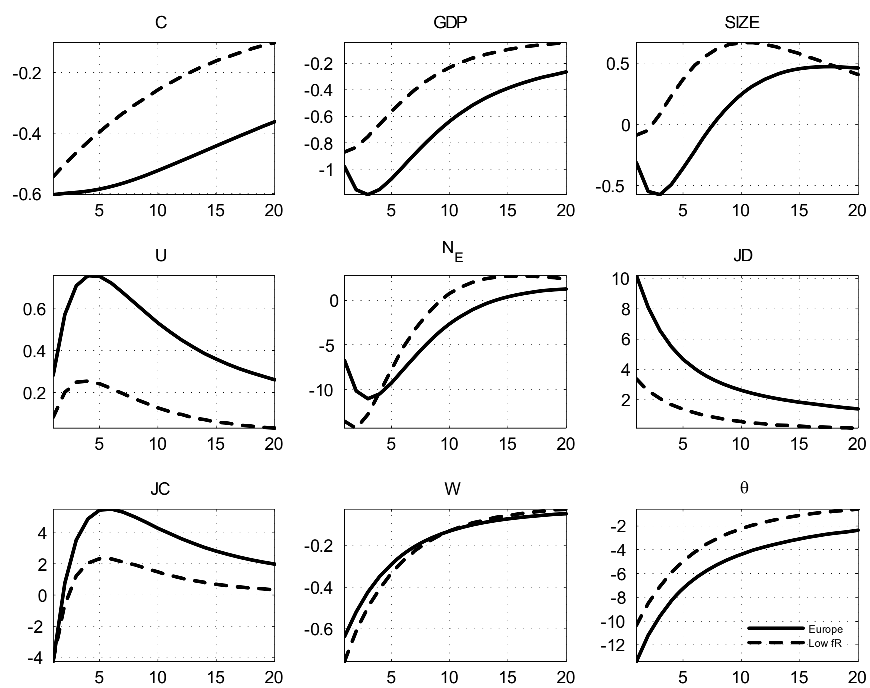

Figure 7. The impulse response function, as percentage deviations from steady state, following a persistent aggregate productivity shock under different level of PMR.

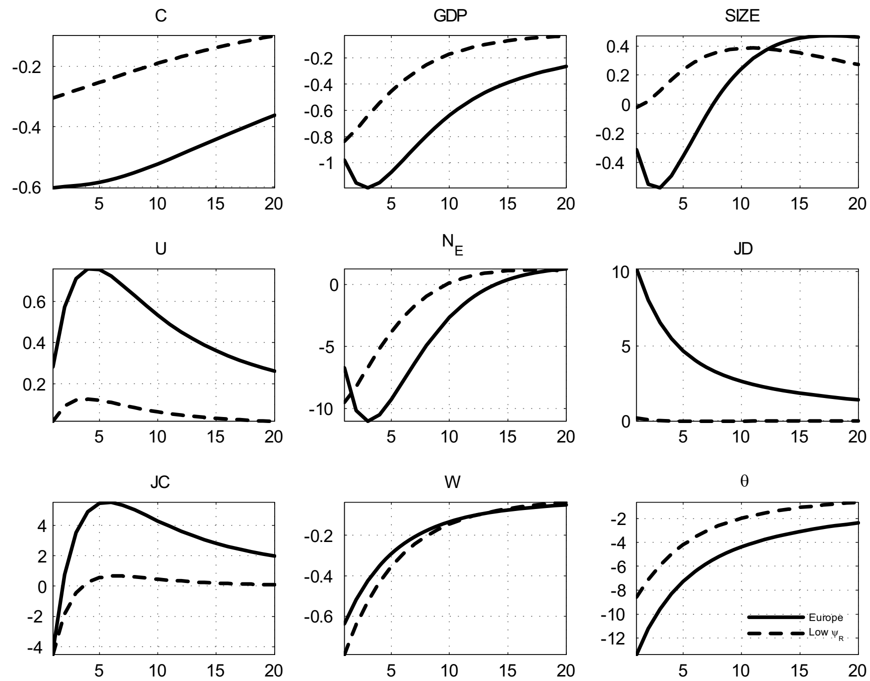

Figure 8. The impulse response function, as percentage deviations from steady state, following a persistent aggregate productivity shock under different size of unemployment benefit ψ_R.

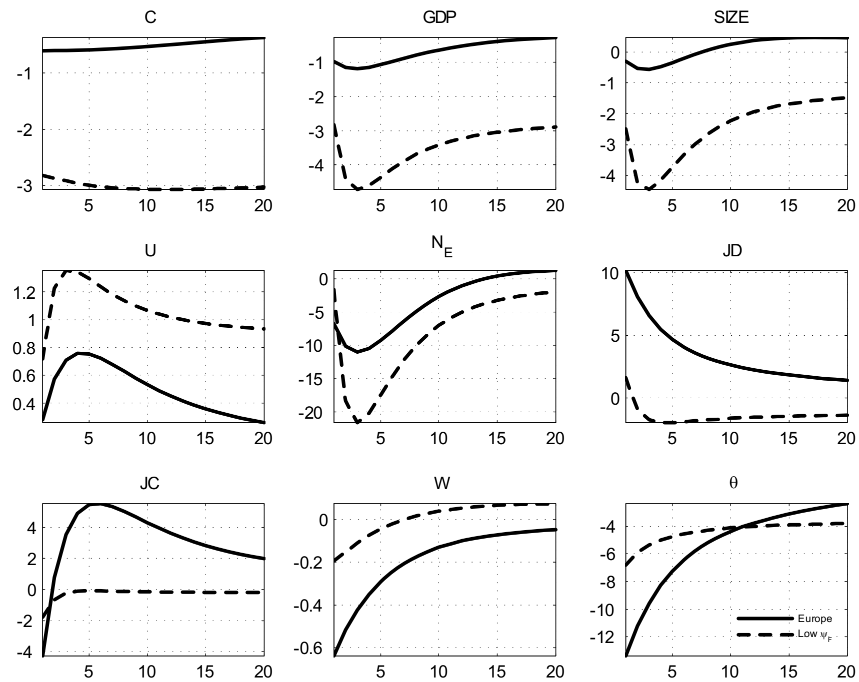

Figure 9. The impulse response function, as percentage deviations from steady state, following a persistent aggregate productivity shock under different size of firing cost ψ_F.

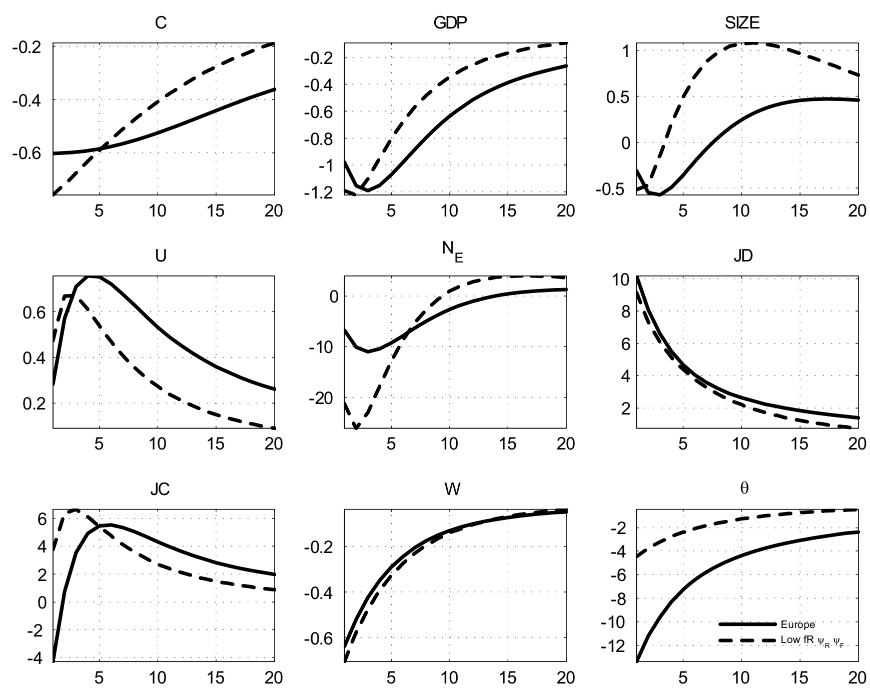

Figure 10. The impulse response function, as percentage deviations from steady state,

after a 1% aggregate productivity shock. Europe with current regulation versus Europe with regulation equal to the one in United States.

Table 3.1: **REGULATION IN EUROPE**

COUNTRY	REGULATION INDEX	REPLACEMENT RATE
AUSTRIA	35.2	63
BELGIUM	25.6	61
FRANCE	39.3	69
GERMANY	55.2	75
GREECE	58.7	55
IRELAND	30.2	49
ITALY	62.9	54
NETHERLANDS	43.7	74
PORTUGAL	35.2	83
SPAIN	84.5	67
AVERAGE	47.05	65

See section 3 for details on the index.

Table 3.2: **SECOND MOMENTS**

	St.Dev.		Corr(Y_t,X_t)		Corr(X_t,X_{t-1})	
Variable X	Data	Baseline	Data	Model	Data	Model
Y	0.75	0.75	1	1	0.92	0.77
C	0.6	0.39	0.81	0.94	0.88	0.73
I	2.36	4.95	0.83	0.96	0.92	0.82
W	0.32	0.33	0.59	0.88	0.72	0.55
U	4.95	4.95	-0.9	-0.9	0.96	0.89
V	n.a.	5.47	n.a.	0.42	n.a.	0.39
θ	n.a.	7.57	n.a.	0.91	n.a.	0.56
Corr(U,V) =	-0.08			.		.
Corr(JC,JD) =	-0.09			.		

3.6.1 Appendix A

Wage Equation

We assume a Nash bargaining between each firm and each worker. Without loss of generality consider a worker with idiosyncratic productivity z_t. The bargaining solution then splits the surplus of their match in shares determined by an exogenous bargaining weight η. The sharing rule is such that:

$$\eta\Gamma_t = (1-\eta)(W_t(z_t) - U_t).$$

where Γ_t is the value of the matched worker for the firm, $W_t(z_t)$ represents the worker's asset value of being matched to a job and U_t is the value of unemployment. We have:

$$\Gamma_t(z_t) = \varphi_t Z_t z_t - w(z_t) + E_t\beta_{t,t+1}((1-\rho_t^f)\bar{\Gamma}_{t+1} - (1-\delta)G(z_{t+1})F),$$

where $\beta_{t,t+1} = \beta(1-\delta)(\frac{C_{t+1}}{C_t})^{-\gamma}$ is the stochastic discount factor adjusted for the exit probability. The value of a job depends on real revenue minus the real wage, plus the discounted continuation value, where $\bar{\Gamma}_{t+1} = \int\limits_{z_{t+1}^c}^{\infty} \Gamma_{t+1}(z)\frac{dG(z)}{1-G(z^c)}$.With probability $(1-\rho_t^f)$, the job remains active and earns the expected value; the job is destroyed with probability $G(z_{t+1})$ and thus there is a firing cost F that the firm has to pay. For W_t and U_t:

$$W_t(z_t) = w_t(z_t) + E_t\beta_{t,t+1}((1-\rho_{t+1}^f)\bar{W}_{t+1} + \rho_{t+1}^f U,$$

where $\bar{W}_{t+1} = \int\limits_{z_{t+1}^c}^{\infty} W_{t+1}(z)\frac{dG(z)}{1-G(z^c)}$.

$$U_t = B + E_t\beta_{t,t+1}(p_t(1-\rho_{t+1}^f)\bar{W}_{t+1} + (1-(p_t(1-\rho_{t+1}^f))U_{t+1}).$$

An unemployed worker receives the unemployment benefit B, the discounted continuation value and the option value of future employment (unless a successful match is destroyed before becoming productive either because of firm exit or job specific destruction).

Inserting the value functions in the bargaining rule yields the equation for the individual real wage:

$$w_t(z) = \eta(\varphi_t Z_t z + \kappa\theta_t - E_t\zeta_{t+1}F) + (1-\eta)B, \tag{3.15}$$

where $\zeta_{t+1} = (1-p_t)E_t\beta_{t,t+1}\rho^f_{t+1}$.

3.6.2 Appendix B

Symmetry between Incumbents

Here we show that: (i) all incumbent firms are symmetric, regardless their period of entry; (ii) optimal hiring policy for a new entrant is to post vacancies to target the end of period size of existing (symmetric) incumbents. We proceed backwards. First we show that it's optimal for new entrants to target the end of period workforce of existing incumbent if entrants in t will have the same marginal cost of current incumbents in $t+1$ Then we complete the proof showing that the real marginal cost is effectively identical for all the producing firm in a given period of time, regardless whether or not the firm is a new producer. Assume that all the producing firm in t - no matter their timing of entry - have the same marginal cost φ_t. This implies that each incumbents is charging the same relative price rp_t since $rp_t = (1+\frac{1}{\sigma N_t})\varphi_t$. It follows that each producer faces the same demand schedule $y^D_t(\omega) = \sigma\ln(\frac{\widetilde{p}_t}{p_t(\omega)})Y_t$. The output produced by each incumbent - expressed in units of the consumption basket C_t - is $y_t = rp_t(Z_t\bar{z}_t(\omega)l_t(\omega))$. In order to ensure that $l_t(\omega) = l_t(\omega')$ it must be that $\bar{z}_t(\omega) = \bar{z}_t(\omega')$, i.e. that each incumbent has the same cut off productivity z^C_t since $\bar{z}_t(\omega) = \int\limits_{z^c(\omega)}^{\infty} z\frac{dG(z)}{1-G(z^c)}$.

Take the job destruction equation for two generic incumbents:

$$\varphi_t(\omega) = \frac{1}{Z_t z^c_t(\omega)}[B + \frac{1}{1-\eta}(\eta\kappa\theta_t - \frac{\kappa}{q(\theta_t)} - (1+\eta\zeta_t)F] \tag{3.16}$$

$$\varphi_t(\omega\prime) = \frac{1}{Z_t z^c_t(\omega')}[B + \frac{1}{1-\eta}(\eta\kappa\theta_t - \frac{\kappa}{q(\theta_t)} - (1+\eta\zeta_t)F]. \tag{3.17}$$

The ratio between those two yields:

$$\frac{\varphi_t(\omega)}{\varphi_t(\omega')} = \frac{z_t^c(\omega')}{z_t^c(\omega)}.$$

Under our guess that $\varphi_t(\omega) = \varphi_t(\omega')$ we obtain that $z_t^c(\omega) = z_t^c(\omega')$ and hence $l_t(\omega) = l_t(\omega') = l_t$. Hence we have proved that if all firms have the same marginal cost, all the shock hitting the economy can be treated as aggregate. New entrants correctly anticipate this outcome and hence find optimal to post vacancies exactly to have a workforce of size l_t. To complete the proof we show that each incumbent has the same marginal cost φ_t regardless the timing of entry. That is the marginal cost depends only on aggregate conditions. Consider the job creation equations for the incumbents ω and $\omega'$and substitute in the corresponding expressions for the wage rates $w_t(\omega)$ and $w_t(\omega')$. This yields:

$$\frac{\kappa}{q(\theta_t)} = E_t\beta_{t,t+1}(1-\rho_{t+1}(\omega))[(1-\eta)\varphi_{t+1}(\omega)Z_{t+1}\bar{z}_{t+1}(\omega) + \Lambda_t)$$

$$\frac{\kappa}{q(\theta_t)} = E_t\beta_{t,t+1}(1-\rho_{t+1}(\omega'))[(1-\eta)\varphi_{t+1}(\omega')Z_{t+1}\bar{z}_{t+1}(\omega) + \Lambda_t)$$

For sure $z_t^c(\omega) = z_t^c(\omega')$ is a solution. We now prove that this is the only possible solution. To do so we show that $F(z_t^c(\omega))$ the right-hand-side of the job creation is monotonic in z_t^c. Plug the job creation. $\varphi_t(\omega) = \frac{\Xi}{z_t^c(\omega)}$, where Ξ depends only on aggregates variables, and take the first derivative of F with respect to z^c :

$$\frac{dF}{dz^c} = -\frac{d\rho}{dz^c}[(1-\eta)Z\tilde{z}(\omega) + \Lambda_t] + (1-\rho(\omega))Z_{t+1}\frac{d\tilde{z}(\omega)}{dz^c} \tag{3.18}$$

where $\tilde{z}(\omega) = \displaystyle\int_{z^c}^{\infty} \frac{1}{z\sigma_a\sqrt{2\pi}} \exp^{-\frac{|\ln z|^2}{2\sigma^2}} dz$. $\frac{d\rho}{dz^c} \geq 0$ since ρ is the cdf of z^c. $\frac{d\tilde{z}(\omega)}{dz^c} < 0$ is a sufficient condition to establish the monotonicity of F. We now show that this is indeed the case:

$$\frac{d\tilde{z}_{t+1}(\omega)}{dz^c} = -\frac{1}{z\sigma\sqrt{2\pi}} \exp^{-\frac{|\ln z|^2}{2\sigma^2}} dz < 0 \tag{3.19}$$

This result completes the proof. Hence $z_t^c(\omega^E) = z_t^c(\omega^I) = z_t^c$, $\varphi_t(\omega^I) = \varphi_t(\omega^E) = \varphi_t$

and hence $l_t(\omega^I) = l_t(\omega^E) = l_t$.

Appendix C

Steady State

Let's express L, M, U, V, p and q as a function of θ and z^c :

$$p = \chi\theta^{1-\varepsilon} \text{ and } q = \chi\theta^{-\varepsilon}$$

$$\rho^T = \delta + (1-\delta)(\rho^x + (1-\rho^x)G(z^C))).$$

Using the law of motion of aggregate employment, the definition of U and the fact that $p = \frac{M}{U}$ we have:

$$L = \frac{p}{p+\rho^T},\ U = 1-L,\ M = \rho^T L$$

From the matching function:

$$V = (\frac{\rho^T L}{\chi})^{\frac{1}{1-\varepsilon}}(1-L)^{\frac{\varepsilon}{1-\epsilon}}$$

Given that $N_E = \frac{\delta}{1-\delta}N$, $e = \frac{1-\delta}{r+\delta}d$ and $d = (1-\frac{1}{\mu(N)})\frac{Y}{N}$:

$$N_E e = \frac{\delta(\mu(N)-1)}{(r+\delta)\mu(N)}Y.$$

At the same time, using the free entry condition:

$$N_E e = \frac{\delta}{1-\delta}N f_E.$$

Equating these two expression we have:

$$Y = \frac{\delta(\mu(N)-1)}{(r+\delta)\mu(N)}f_E = \frac{\delta}{(r+\delta)(1+\sigma N)}f_E,$$

where $\mu(N)= 1+\frac{1}{\sigma N}$ and $f_{E,t} = f_{R,t} + \kappa \frac{\delta}{1-\delta} \frac{L_t}{q(\theta_t)}$. The steady state average wage rate can be written as:

$$\bar{w} = \eta(\frac{\sigma N}{1+\sigma N} e^{-\frac{\tilde{N}-N_t}{2\sigma \tilde{N} N_t}} Zz + \kappa\theta - \zeta F) + (1-\eta)B,$$

where we used the fact that $rp = (1+\frac{1}{\sigma N})\varphi$ and $rp = e^{-\frac{\tilde{N}-N}{2\sigma \tilde{N} N}}$. Hence: $\varphi = \frac{\sigma N}{1+\sigma N} e^{-\frac{\tilde{N}-N_t}{2\sigma \tilde{N} N_t}}$.Combining the aggregate resource constraint and the definition of aggregate demand:

$$Y = \overline{w}L + Nd + kV,$$

which can be written as:

$$\frac{\delta \sigma N}{(r+\delta)(1+\sigma N)^2} f_{R,t} + \kappa \frac{\delta}{1-\delta} \frac{L_t}{q(\theta_t)} = (\eta(\frac{\sigma N}{1+\sigma N} e^{-\frac{\tilde{N}-N_t}{2\sigma \tilde{N} N_t}} Zz + \kappa(\frac{\rho^T L}{\chi(1-L)})^{\frac{1}{1-\varepsilon}} - \zeta F) + (1-\eta)B) + k(\frac{\rho^T L}{\chi})^{\frac{1}{1-\varepsilon}} (1-L)^{\frac{\varepsilon}{1-\epsilon}} \tag{SS1}$$

We still have to use two equations, namely job creation and job destruction:

$$(1-\beta(1-\rho^T)) \frac{\kappa}{\frac{\rho^T L}{(\frac{\rho^T L}{\chi})^{\frac{1}{1-\varepsilon}} (1-L)^{\frac{\varepsilon}{1-\epsilon}}}} = \beta(1-\rho^T)[\frac{\sigma N}{1+\sigma N} e^{-\frac{\tilde{N}-N_t}{2\sigma \tilde{N} N_t}} \bar{z} - (\eta(\frac{\sigma N}{1+\sigma N} e^{-\frac{\tilde{N}-N_t}{2\sigma \tilde{N} N_t}} Zz + \kappa\theta - \zeta F) + (1-\eta)B)], \tag{SS2}$$

$$\frac{\sigma N}{1+\sigma N} e^{-\frac{\tilde{N}-N_t}{2\sigma \tilde{N} N_t}} z^c = [B + \frac{1}{1-\eta}(\eta\kappa(\frac{\rho^T L}{\chi(1-L)})^{\frac{1}{1-\varepsilon}} - \frac{\kappa}{\frac{\rho^T L}{(\frac{\rho^T L}{\chi})^{\frac{1}{1-\varepsilon}} (1-L)^{\frac{\varepsilon}{1-\epsilon}}}} - (1+\eta\zeta)F] \tag{SS3}$$

Recalling that $L = \frac{p}{p+\rho^T}$ and $\rho^T = \delta + (1-\delta)(\rho^x + (1-\rho^x)G(z^C)))$, we have a system of three equations -SS(10), SS(2) and SS(3) - in three unknowns : p, z^c and N. Solving for these three unknown variables as a function of model parameters allows us to determine the entire steady state of our model economy.

Appendix D

Calibration

A crucial aspect of our model is the distinction between within and across firm worker separation, a feature absent in a standard "large firm" model of search and matching frictions. To pin down δ and ρ^x we use the following procedure.

First notice that total job destruction in steady state is given by $jd = \rho^T L - (1-\delta)\rho^x qL$. The amount of the overall job destruction induced by the exit of plants is $jd^{EXIT} = \delta L$.

? report that over the period 1995-2000, the ration $\frac{jd}{L}$ in countries belonging to the Euro area ranged between 3.1% to 4.3%. We choose midpoint value of 3.5% as our target. At the same time, several studies for countries belonging to the Euro area report values of $\frac{jd^{EXIT}}{jd}$ ranging from 31% to 53% - see OECD (1994). Again, we choose an average value of 40%.

By assuming a total separation rate ρ^T of 4%, we can compute δ and ρ^x as follows:

$$\delta = \frac{jd^{EXIT}}{L}\frac{jd}{L}$$

$$\rho^x = \frac{\rho^T - \frac{jd}{L}}{(1-\delta)q},$$